SCIENCE

A WEEKLY JOURNAL DEVOTED TO THE ADVANCEMENT OF SCIENCE, PUBLISHING THE OFFICIAL NOTICES AND PROCEEDINGS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

FRIDAY, FEBRUARY 8, 1907.

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MSS. intended for publication and books, etc., intended for review should be sent to the Editor of SCIENCE, Garrison-on-Hudson, N. Y.

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE INFLUENCE OF PARASITISM ON THE HOST[1]

THE line of development within the field of zoological research has shown a distinct tendency within recent years to move in the direction of biological study, to view the organism as a living thing and to seek an explanation for the various problems of life which present themselves in connection with it. One of the earliest phases of biological study found its origin in the condition presented by parasitism. The class of Helminthes, or intestinal worms, of the earliest authors, was seen early in the course of morphological study to be unwarranted as a systematic grouping. The animals included under the term were not those which were in any genetic sense related to each other. Like the earlier designations of land animals and water animals, these forms were grouped together by virtue of similarity in conditions of existence. The term is accordingly a biological one and its purely biological significance was stoutly maintained as early as 1827, by the great embryologist, Carl Ernst von Baer, and by F. S. Leuckart. The idea received finally due acceptance through the efforts of Carl Vogt, who dissociated the earlier group and united its subdivisions with those free living animals to which they were most closely morphologically con-

[1] Address of the vice-president and chairman of Section F—Zoology, American Association for the Advancement of Science, New York meeting, December, 1906.

nected. Even thus early it was apparent that parasitic animals were derived from free living forms, that they were in fact but degraded members of the same groups; in some cases with such little modification in structure that their affinities were recognized at a glance, in other cases, however, the excessive modification had carried the parasitic form very far from the ancestral type, and yet the existence of a large number of intermediate stages suggested at once that these changes had been gradual.

In spite of the fact that these studies were among the very earliest of biological investigations, it appears that the reciprocal influence has rather generally escaped discussion. It is my desire, accordingly, in so far as may be practicable within the limits of time and space of a single address, to set before you the main facts in connection with this other side of parasitism—the influences which are exerted upon the host animal, the changes wrought in it, and the part they play in the problems of general biology. There is a vast amount of information and detail regarding individual species; and in some cases the relations have been investigated with great care from the standpoint not only of the morphologist and of the physiologist, but even also from that of the chemist; but in the main these observations stand as isolated and unrelated facts. I have neither the knowledge nor the ability to bring them all together into a concrete whole, but there are certain general headings under which it is possible without especial effort or explanation to group some of the phenomena, while others must wait for better knowledge or clearer perception than I possess before they can be included in any generalizations.

In rough fashion it is the custom to class parasites as harmful and harmless. The harmful forms induce pathological changes, stand in some definite relation to disease and become, accordingly, of prime importance to the investigator in medical fields. The other forms, while spoken of as harmless or without effect, certainly should not be classed as exercising none. With the exception of certain striking instances, especially among those forms which parasitize man, the effects of parasitism are almost unknown, hence they are largely ignored. In the course of time opinions on this matter have changed radically. As I have said in another paper:

"In the belief of the medical profession two hundred years ago there was no disease, real or imaginary, which was not due to the presence and effect of some kind of parasite. Each ailment had its particular 'worm' in its characteristic location. This was a direct result of the endeavor to reduce every malady to some definite cause, and from a joining of the unknown sickness with the parasites, of which they knew as little. Under the influence of study and of increase in knowledge regarding the parasites, such a theory was seen to be untenable, and the movement in the opposite direction began—a tendency which may be said by this time to have passed its height. In fact, there has prevailed during recent years among the medical men of this country an exaggerated idea of the unimportance of human parasites." This must give way to a proper conception of the pathological significance of these organisms, based upon careful investigations of their actual influence upon the host.

Yet there are some parasites of which it may fairly be said that even careful study has failed to show any manner in which they affect the host. Thus Looss records of a distome (*Heterophyes*) commonly found in the human alimentary canal among Egyptian laborers, that, although present in considerable numbers, most careful scrutiny fails to disclose any influence which it exerts upon the host. This is

traceable to the fact that it neither burrows into nor feeds upon the mucous lining of the canal, but contents itself with taking its food from the partially digested contents of the intestine. Inasmuch as the organism is very small, this is evidently a negligible factor in the economy of the host; but even here, as I shall show later, there is the possibility that under some circumstances the organism may become a menace. Again, *Filaria loa*, the African eye worm, lives for many years in the connective tissue of the human body, wandering from point to point, often not far below the skin. In the course of its migrations it does apparently no injury to the host, who is indeed unconscious of its presence until it happens to come into the connective tissue over the surface of the eyeball. Here it appeals to the sense of sight, and from here it has most frequently been extracted. But in this case again there are swellings which appear from time to time on the surface of the body and which are believed by some to be due in one way or other to this parasite.

In the group of indifferent bodies we must also include many, if not all, of the resting forms, those which, like the bladder worms, or the young trichinæ, are encysted at a given point and which consequently are not to any appreciable extent absorbing nutrition or producing toxic materials. The encapsulated trichina is but a grain of sand, the encysted bladder worm no more than a globule of fat in the tissue. During its entire life in the body the guinea worm does not seem to exercise any influence whatever upon the host organism until the female appears at the surface and is desirous of securing an opening through which it may discharge the young into the outer world, where they will find conditions for further existence.

These few preliminary statements have paved the way for a somewhat clearer general idea of the factors which determine the degree of influence exerted by the parasite on its host, and the first is evidently the numerical factor. Commonly, the single parasite leaves no effect; it is the multiplication of parasites which is to be feared. Evidently this multiplication will be most serious when it takes place within the host and leads directly to a multiple infection. This is known among the protozoa, where, in at least one host, there is usually a recurrence of generations of the same type, and this feature is so characteristic that Doflein designates this cycle of the life history as the multiplicative cycle, defining its purpose as being to achieve the multiple infection of the host. There are also some worms among the Nematodes in which the same thing takes place and by virtue of which the infection of the alimentary canal is enormously increased in direct fashion.

Among most metazoan parasites, however, including all Trematodes, Cestodes and some Nematodes, such is not the case. The eggs of the individual must be transported to the outer world before they can carry out their development, and they reach a new host after a more or less complicated life history which may involve alternation of generations and parasitism in one or more intermediate hosts, so that when the stage comes in which the infection of the first species is possible, it is very unlikely that the original individual will be reinfected. Among such parasites the effects from a single individual are not serious and the real danger lies in a multiple infection through the increase in numbers which such a species often experiences in the intermediate host, or within a limited area in the outer world, so that by the taking in of a single external object a large number of parasites may be introduced. Where alternations of generations exist the dangers of the parasitic existence are so great

that the number of parasites is kept down. Yet under a favorable combination of circumstances the numbers of a given parasite may be enormously increased and with this the dangers from the species also enhanced.

Naturally, immediately related to the factor of numbers is the question of comparative size. In a general way the effects of a parasite are related to its mass as compared with that of the host, and this will be clearly manifest in the subsequent discussion. From a special point of view, however, this is absolutely untrue and the secondary effects of an individual species may be out of all proportion to its size. This will also receive more detailed discussion at a later point.

Evidently, both of the factors which have just been mentioned are largely relative and distinctly such with regard to the seat of the injury, *i. e.*, the organ of the body which is attacked; thus a parasite may be quite harmless if located in connective tissue, or between the muscle fibers, while if the same specimen were to be located in the brain or in the eye its effect would be very serious. A small organism would pass entirely unnoticed in the alimentary canal, but in the heart or blood vessel, it might well cause serious disturbances, or under certain conditions even the death of the host, so that the pathogenic significance of a parasite depends essentially upon its location.

The effects of a parasite on the host may be roughly classified as mechanical, morphological and physiological. To be sure, a sharp separation is not possible at all points and frequently the one influence involves concurrently or subsequently such as belong to another group.

Animal parasites, for the most part, produce only local changes and these are explicable on purely mechanical grounds, or they are structural or functional within limited areas. But physiological influences sometimes manifest themselves as symptoms of a general disease. Such manifestations ordinarily accompany the multiplication of the parasite within the host or at least its presence there in large numbers.

Many of the effects upon the host produced by parasites may be explained in purely mechanical fashion, and under this heading are included those which produce even some of the more complicated and far-reaching results of parasitic infection through the secondary effects which they induce.

Regarding the parasite as a passive mass, a purely inert body, it may bring about a stoppage of various passageways and thus induce serious consequences for the host. Such an occlusion of a canal may follow under perfectly normal conditions, but more frequently there is something unusual that tends to induce the condition; either that the parasite is in an abnormal location or that some factor enters into its normal habitat to aid in purely mechanical fashion in the stoppage of the passageway. Thus, the accumulation of a group of common round worms into a ball will suffice at times to occlude entirely the alimentary canal, and the worms, tangled and twisted together, stop the passage of food materials and waste. Unless the condition is accurately diagnosed and promptly alleviated by operative means, this stoppage of the canal results in the death of the host. Such has been the result in man in several cases on record and similar instances are more frequent among other hosts. But in one of the more carefully investigated cases it was found that the mass of seventy-two ascarids were inextricably tangled together by a long hair swallowed by accident and in some way twisted tighter and tighter through the contortions of the parasites.

The young sclerostomes of the horse live in the large arteries of the abdomen. Their presence in these arteries explains

the aneurisms frequent at this point, as they obstruct the vessels and raise the arterial tension behind the points where they have formed a blockade. This induces in a purely mechanical way a distension of the vessels at the region of increased pressure.

Even much more complicated changes in the host may be reduced in final analysis to a mechanical effect. In the case of the Egyptian blood fluke, the female goes into the venous plexus of the pelvis to oviposit and the oval eggs which are supplied with a rudimentary spine at one end are carried into the capillaries by the blood current and there gradually work their way through the wall of the alimentary canal, or the urinary bladder, so as to reach the cavity of the organ and to escape from the body. The large numbers of these eggs which are produced fill up the capillaries, interfere with the flow of blood, lacerate the capillary walls and tissues through which they are forced mechanically until a series of serious changes is invoked in the organs in question. The condition is even more serious when these same eggs chance to be carried about the body of the host by the circulating blood, become entangled in the capillary network at different points and constitute the foci of small emboli. Such may arise in the brain where retardation of the blood current and the resulting emboli are sources of serious danger to the host, since they give rise to brain tumors and may evoke apoplectic symptoms. The effects produced by such brain tumors of parasitic origin do not differ from those of other tumors or other foreign bodies. All of these effects are at basis mechanical and the same results would apparently be produced by any inert bodies of similar form and number.

One may go still further and call attention to the fact that in some cases it is a mass of embryos which constitute the mechanical influence at the basis of serious changes. Some of the filariæ which inhabit the connective tissue are viviparous and produce countless numbers of embryos; these are carried by the lymph and blood stream all over the body; accumulating, evidently by chance, in considerable numbers at certain points of the lymph vessels, for instance, they act mechanically to produce lymph stasis and dilation of the parts. The long-continued working of this cause will produce an enormous distension of some regions of the body, giving rise to one form of the condition which is known as elephantiasis.

Another mechanical influence of the passive parasite is traceable to the pressure which it exerts upon surrounding tissues. In so far as the parasite is stable this pressure will be constant and its effect is of minor consequence; however, whenever the parasite is in a condition of active growth the gradually increasing pressure becomes an important element to consider, but the discussion of this falls naturally under a subsequent heading.

There are certain influences which the parasite exerts that are mechanical, and still are not traceable to it as a mere inert body; they rather are determined by its activity, and yet they properly deserve consideration under this head, for the parasite, though active, is exerting a purely mechanical influence, and one might conceive of the same results following upon the movement of any inanimate object. If the parasite moves about it tends to irritate and inflame or destroy the surface upon which it lies, even though it remains relatively fixed in location and merely twists from side to side. The irritation here will be evidently local and will be due to, or at least emphasized by, the spines or other roughness of the body. It will be also increased if the parasite possesses suckers or other organs of attachment. The delicate

mucous surfaces with which the parasite usually comes in contact are of all parts of the body the most susceptible to injury in this fashion, and, as we shall see later, many parasites combine with the mechanical lacerations of tissue by movements and their hold-fast organs, a physiological influence of far-reaching import.

A complicated case which indicates the combined effects of mass and motion, with possibly additional features of a physiological character not yet well understood, is illustrated by the smaller liver flukes of the genus *Opisthorchis*. These species occur in the gall ducts of the liver and there they evoke changes which, though radical, are in general uniform for different species and hosts. As the flukes advance into the finer canals of the liver, the ducts become completely occluded. The first result is bile stasis and consequent dilation of the canal until this acquires considerable size. Both the epithelial layer and the connective tissue of its wall undergo profound modifications. The epithelium shows an active catarrhal irritation. The glands manifest considerable hypertrophy. Many new accessory ducts are formed alongside the original one. Among the secondary effects one may note that while the connective tissue proliferates actively and acquires enormous thickness, the liver tissue undergoes granular degeneration as the cells gradually atrophy, thus the functional portion of the organ is gradually replaced by inert tissue. The arrest of the bile is followed by digestive disturbances and compression of the branches of the portal vein produces venous stasis, from which follows naturally the ascites so frequently observed in the course of the malady. Now all of these modifications follow the mechanical stoppage of the duct naturally, though no doubt the effect is increased by the irritation produced by the movements of the parasites. Some investigators hold that the flukes feed upon the mucous lining of the ducts; this is true of other liver flukes, but according to my observations does not apply to *Opisthorchis*.

Parasites, however, not only carry on movements through their natural territory, but they also from time to time indulge in migrations, the causes of which are not clear, but the effects are serious in the extreme.

The extent of such abnormal migrations is well illustrated by *Ascaris lumbricoides*. This form has been known to migrate along evident pathways from the duodenum into the biliary ducts, and liver, where it has induced hepatic abscesses, or into the pancreas with like results, into the larynx and trachea with the result of suffocating the host, into the eustachian tube to emerge from the auditory canal after perforating the tympanic membrane, or even into the frontal sinuses, or the internal angle of the eye.

Such erratic parasites do not always confine themselves to normal passageways of the body. Even where the penetration of tissue is distinctly exceptional, it not infrequently happens that under some unknown stimulus the species brings itself to transgress natural limitations and to open an abnormal communication between regions otherwise entirely separated. Ascarids have perforated the intestine, penetrating the peritoneal cavity, have come out from abscesses at various points, or have been discovered on the occasion of a post-mortem in the most varied regions of the body. The liver fluke as it feeds upon the hepatic cells may chance to open a small vessel, or the lung fluke may similarly effect an entrance into the circulatory system and either be thus carried into distant and unnatural parts of the body, reappearing in abscesses, and in expansions of the eyelids, or being caught in brain tumors, which sooner or later arouse the disturbances that

naturally result from the presence of foreign bodies in that organ.

The migrations of smaller forms, even though they may be numerous, are not accompanied ordinarily by the same effects as those of larger species, since the orifices they make are sufficiently minute to close immediately after the animal and prevent the secondary effects which are due to such abnormal connections. Thus the minute embryo of tapeworms migrate from the alimentary canal to the point of encystment without influencing appreciably the host, and other larvæ migrate through the tissues with such little disturbance that unless the numbers be large the host suffers no inconvenience.

Emphasis should be laid upon the extreme importance in the economy of the host which the secondary effects exert. The abrasion and destruction of surfaces and cells and the opening of abnormal communications is not *per se* of such vital importance as the results which may follow through the admission of bacteria from the canal into the blood and tissues of the animal. It is frequently held that the uninjured mucous surface is resistant to the action of bacteria and that typhoid and cholera germs must depend to some extent upon diminished resistance, functional or structural, for their original introduction into the tissues of the body. It is certainly true that many pathogenic organisms exist in the alimentary canal without detriment to the host animal, although if permitted to pass into other parts of the body they excite immediately dangerous symptoms. The perforations of the intestinal wall by *Ascaris* and the escape of such organisms into the body cavity gives at once the conditions for a serious if not fatal peritonitis, and *Ascaris* is not alone in this respect.[2]

Examples of this can be multiplied, but one will suffice. In the etiology of appendicitis certain factors are regarded as predisposing, others are direct causes of this malady. As early as 1724 Santorini recorded the presence of worms, probably *Trichuris*, in the appendix. Numerous later authors found at necropsies *Ascaris* and trichurids in this organ, as well as calculi containing eggs of *Ascaris* and *Oxyurias*. In 1901 Metchnikoff noted that in several persons who manifested symptoms of appendicitis when microscopical examination of the feces demonstrated the eggs of *Ascaris* and of *Trichuris*, the administration of a vermifuge effected a cure. He maintained that nematodes were the cause of many cases of this disease and explained the rôle of the parasites as first a direct mechanical or chemical action on the appendix and second an indirect action by the introduction of microbes into the mucosa. Metchnikoff did not commit the error attributed to him by some authors of regarding all cases of appendicitis as of parasitic origin, but specifically stated that there are certainly appendicites of different origin. Subsequent authors furnished additional evidence of the direct or indirect action of parasites in producing appendicitis, while others, though admitting the possibility that nematodes may inoculate the intestinal mucosa with bacteria, regarded this as an inappreciable factor in

[2] Piana was the first to note that the migration of *Cysticercus pisiformis* into the liver of the rabbit could introduce bacteria. In two cases of tubercular peritonitis of dog associated with *Dioctophyme renale* in the abdominal cavity Galli Valerio advanced the view that migration of the nematode made possible the development of the bacillus or carried it into cavity. It has recently been clearly shown that the pin worm, *Oxyurias*, has burrowed into the wall of the canal and produced there microscopic ulcerations, while it seems probable that it has actually made its way through the wall into the cavity of the pelvis. This perforating action places *Oxyurias* also in the ranks of parasitic introducers of bacteria.

appendicitis since their presence in this organ constitutes a pathological rarity.[3]

Evidently in producing ulcerations of the intestinal mucosa parasites facilitate the absorption of toxins from the canal and permit the inoculation of this layer with pathogenic bacteria from the intestinal contents. They can thus be the agents of inoculation for numerous diseases. Guiart, who defends this view most strongly, believes that intestinal parasites play an important rôle in the etiology of diseases of the intestine and liver, such as insects play in the etiology of blood infections. He advances evidence to support the view from the records of both human and comparative parasitology. While recognizing fully that the infections are bacterial, he emphasizes the necessity of some inoculating agent as in a sense the most important element, since pathogenic bacteria are generally present in the alimentary canal. No one can doubt, he maintains, that Eberth's bacillus is the agent of typhoid fever, but there is reason for regarding it as innocuous if the intestine is undamaged. In a population drinking contaminated water only a few persons in reality are infected. Any intestinal parasite capable of inflicting a wound may infect the host if the bacillus is present. The infecting agent may be an Ascarid, a hook worm, a fly larva; most commonly Guiart believes it to be the whip worm (*Trichuris*) which bores into the folds of the intestinal mucosa with its attenuated anterior end. This parasite Guiart calls the lancet of inoculation and demonstrated its presence in eleven out of twelve typhoid cases in one group. It is interesting to note that in 1762 this species was looked upon as the cause of typhoid and its abundant presence was noted in many epidemics by early investigators. After having gone to the opposite extreme, scientific opinion now shows a tendency to return to its earlier position and to regard the parasite an active factor in the introduction of the disease.

This unfortunate function as introducers of bacteria is, however, not confined to intestinal parasites. The chigo, or 'jigger,' a sand flea of some tropical regions, which burrows into the feet of natives, renders its host thereby exceedingly liable to infection, which in its secondary effects in the tropical clime, makes of a trivial injury one of serious consequence. The guinea worm, which burrows through connective tissue, approaching the surface at the time when it desires to deposit its embryos and producing there small ulcers or openings to the exterior, menaces the well being of its host, not by virtue of its own activity, but through the chance for infection to which it has subjected the host.

Parasites in many cases produce morphological or structural changes in their hosts, which may be classed in general as progressive histological changes in that they lead to the accumulation of material through the multiplying of the host cells.

Billroth indicated the extremely important fact that the multiplication of epithelial cells is caused by infection with micro-organisms and it has been shown that protozoa as well as bacteria may cause infected cells to multiply. Thelohan has shown that myxobolid infection produces a proliferation of muscle cells. Hofer and Doflein ascertained that in kidney infec-

[3] Galli-Valerio has subjected a recent fatal case of appendicitis to most careful examination and finds in the contents of the perforated appendix numbers of *Oxyurias vermicularis* and eggs of *Trichuris*, while sections demonstrated numerous perforations of the mucosa made apparently by the parasites and in one case the worm still within the tissue. Neither the presence of the parasites nor the evidences of their work could have been determined without a microscopic examination, and in view of the usual lack of such examination this is sufficient answer to the objections cited above to the probable rôle of parasites in the etiology of this disease.

tion by myxobolids increased growth in the skin resulted. It is also a distance effect, if not so great, when according to Leuckart the epithelial cells in coccidial nodules of the rabbit liver increase strongly in numbers. Among the epizoa there are many which produce such growths in the epithelium. The various species of itch mites excite a proliferation of the cells until there are formed crusts or thickened masses of considerable extent in which the galleries of the mites are constructed. These proliferations are said to be due merely to the mechanical stimulus exerted by the mites, and the crusts are formed by the addition of serous exudates. Such formations are thoroughly characteristic of the work of these parasites. Less well known are other cases of the same type such as that of gall-producing copepods which infest actinia.

But such stimulation is not always purely indefinite. Parasites often produce unusual forms in the region of the host in which they reside; thus, Woodworth, examining a skull of the common skunk, found that prominent swellings in the frontal bones near the sagittal plane were due to a nematode. The bone was extremely thin and in the subjacent frontal sinus lay a nest of fifteen to twenty of these parasites. The belief was expressed that the prevalent frontal enlargements of other American Mustelidæ are probably due to the same parasite.

Perhaps the most common form of morphological change on the part of the host is the production of a cyst about the parasite. It is composed in most instances, in part at least, by the host animal, and consists in its simplest form of an enveloping mass of connective tissue. This reaction against the invasion of the parasite is found in almost all groups.

The formation of pearls appears to be due regularly, if not exclusively, to the intrusion of parasitic larvæ. The host responds to the mechanical or chemical stimulus of the in-wandering larva by producing an epithelial sac which surrounds the parasite. Such a cyst formation by the host very generally follows when a parasite settles down to enter upon a resting stage in the body of the host. But here the character of the cyst wall leads normally to the formation of a deposit of lime of the same sort as the inner lining of the mollusk shell and the larval parasite becomes the nucleus of a pearl. This stimulus to pearl formation is not given by any particular species of parasite, but is traceable even to members of different classes of animals. Thus in European mussels pearls are formed about the cercariæ of Trematodes.[4]

But in the Ceylon pearl oyster, which is more nearly related to the mussels than to the oyster, the formation of pearls is due to certain cestode larvæ which undergo a portion of their development in the tissue of the liver, gills and mantle of the pearl oyster. Of these larvæ, such as for some yet unexplained reason do not succeed in carrying out their life cycle, become immured in the center of a pearl. Shipley and Hornell, who have investigated with success these phenomena, say "economically these unpleasant little creatures are of supreme importance to the Ceylon pearl fishery, as their presence in the oyster causes the formation of the finest quality of pearl and those of the highest luster." Another economic factor may be merely noted in passing. In 1859 Kelaart called attention distinctly to the possibility of infecting other beds with the larvæ of the pearl-producing parasites in order to increase the quantity of pearls. Beds of

[4] In one case carefully elucidated by Jameson the adult fluke inhabits the eider duck and the scoter, its sporocyst occurs in the cockle, while the tailless cercaria is found in the mussel and forms the nucleus of the small, lusterless pearls of that species. Another trematode is the cause of pearl formation in the fresh-water anodons.

Ceylon pearls might thus be grown in other parts of the world. Kelaart says that the nucleus of an American pearl, drawn by Möbius, is of nearly the same form as that found in the pearl oyster of Ceylon.

It is interesting to note in comparison the record of Johnstone that in the gurnard small pearl-like bodies are found adhering to the peritoneal investment of the intestine. The concretion is made up of a great number of concentric lamellæ which seem to consist of wavy bundles of connective tissue. These structures are probably derived from *Tetrarhynchus* cysts from which the larvæ had escaped and which had then undergone calcareous degeneration.

The amount of growth may be much greater than thus far indicated and a condition among animals closely analogous to the formation of galls on plants has been observed by Nutting. In certain Alcyonaria a tunnel formed of excessively enlarged spicules is found along one side of the stem or branch. The abnormal structure is due to an annelid. Greatly enlarged polyps in another genus owe their origin to the presence of crustacea or some other form of parasite.

Continued efforts have been made to demonstrate that the extensive pathological growths found in animals are due to the stimuli exerted by minute parasitic forms. It has been shown that in plants such abnormal growths are due to the encroachments of parasites; but the effort to identify animal organisms as the cause of cancerous and other abnormal growths has in the opinion of most investigators failed to establish a case.

When we seek to ascertain the causes of the morphological changes which result from the influence of the parasite on its host it is difficult in the present state of knowledge to find any very definite explanation. Localized growth is ordinarily a factor of differentiation, but here it has no reference whatever to that process. Davenport in his admirable treatise on experimental morphology has given a very clear discussion of the factors in the effect of chemical and physical agents upon growth, and has brought together the evidence which shows the acceleration of growth by contact, by cutting and by chemical stimulus. Now an examination of the cases in which growth is induced by parasites leads to the conviction that neither contact nor cutting can be a stimulating factor, since there are too many cases of parasitism in which no growth is produced, while in the exceptional case the presence of the parasite stimulates considerable growth activity. To be sure, it has already been suggested that the formation of a cyst about a resting parasite is a normal activity of the host and occurs very generally if not universally. This may be the result of a contact stimulus; it may also be explained on the same basis as the other cases, viz., as a result of chemical stimulus. Under the discussion of the acceleration of growth by chemical stimulus, Davenport says: "It is clear from this table that the addition of even small quantities of innutritious and poisonous substances may so affect the hylogenic processes as to cause twice or even far more than twice the normal formation of dry substance in a given time, and that this excessive growth increases with the concentration of the poisonous substances up to a certain optimum beyond which growth declines again to below the normal."

In suggesting that the stimulation of growth by parasites is traceable to chemical stimulus, and that the stimulating substance is a poison, I am advancing a hypothesis which, even though it is a purely tentative one, may well engage our consideration for a moment. Each parasite in the course of its activities produces a certain amount of waste material. It may

safely be affirmed that this substance, which in the case of a resting parasite must be discharged directly into the tissue of its host, is to that tissue poisonous. If such material is given off in small amount it will evidently act as a stimulant upon the surrounding cells and be the factor in bringing together the leucocytes which accumulate about the invading organism. An inert body of the same size, if introduced into the same position, would not induce the formation of a cyst or certainly the tissue proliferations which accompany in some cases the attacks of parasites. It may even be doubted whether under the conditions for pearl formation, grains of sand, as formerly believed, will give the proper stimulus for the formation of the pearl. The important factor then must be one which is associated with the organism, not as an object occupying space, but as a living thing, and the most evident characteristic of this is the giving off of waste matter. This leads naturally to the next subdivision of the subject.

As physiological effects may be grouped together those influences of the parasite on the host which express themselves in the limitation or modification of the normal physiological processes of the latter. In some cases it is often true here that the primary effect is hidden and that the secondary result alone can be seen. It is sometimes possible to determine the primary result by study of the secondary, and to see the way in which it has been brought about. In other cases we merely know the secondary effects without being able to disentangle from the complicated series of phenomena the primary cause. Furthermore, those interferences with normal function which are grouped under this heading are not such as might be traced to the action of the parasite as a foreign body, but such as are related to its own activity as a living organism. It will be seen that the distinction here is not perfectly clear, and perhaps somewhat artificial, for the mechanical disturbances of parasitism interfere with the normal activities of the host in the same way that other foreign bodies may modify or limit the working of the same organism. However, it is my intention under this heading to consider the results which come from the contact of life with life, the interaction of function with function.

Perhaps the most evident factor and the most frequently mentioned, certainly the first to be noted in this connection, is the absorption of nutriment. The parasite demands a certain amount of food matter to carry on its own vital processes. This food matter is furnished, so far as endoparasites are concerned at least, in a partially or fully digested condition, by the host animal. Many observers have maintained that the actual loss to the host in this way is so slight as to be negligible.

Leuckart says that a *Dibothriocephalus latus* 7 meters in length weighs 27.5 grams, and gives off in a year a total of 15 to 20 meters of proglottids of a weight of approximately 140 grams, and that *Tænia saginata* produces daily on the average 11 proglottids, an amount equal to about 550 grams. These figures have been taken by some to indicate the actual loss of food material on the part of the host; this would be evidently insignificant in comparison with the amount consumed by a man within the year. It has even been suggested that the increased appetite induced by the presence of the parasite more than compensates for this slight loss. It would appear, however, that such a method of statement is exceedingly inadequate. It is very difficult to estimate the amount of food consumed by an animal in proportion to its weight, but it is certainly grossly insufficient to indicate this in any way as commensurate with the amount of growth

which the animal achieves within a given period.

There is also another factor which must be taken into account, viz., that the parasite consists almost exclusively of actively functioning organs, and that there is a minimum of such inert parts as skeletal structures which add greatly to the weight of an animal, but do not involve the consumption of food material for their maintenance. It has been shown recently that parasites contain a large amount of glycogen; in analyses from one fourth to one third of the dry weight consists of this material. The highest value previously known was 14 per cent. in *Cardium* (a mollusk) and mammals apart from the liver have only about 3 per cent. Later the same author (Weinland) demonstrated that the vital processes of *Ascaris* proceed without oxygen and involve a fermentation process, resembling that of bacteria and yeast in producing butyric acid and alcohol. The possibility of such a wasteful process, measured in calories actually used, is found in the especially favorable conditions of existence of the parasite, which afford it carbohydrates in superabundance and both protection and warmth from the host. But naturally the waste of the process means draft on the host.

Furthermore, the presence of the glycogen, which is unquestionably reserve material, indicates unmistakably that metabolic processes are exceedingly active in the organism. Another indication of the same thing is to be found in the reproductive activity. The tapeworm is producing and maturing an enormous number of eggs, each of which is supplied with a considerable yolk dowry. It is safe to affirm that during reproductive periods the draft of any animal upon its food supply is at a maximum. All of these three items, then, the rapid growth of the individual, the production of an unlimited supply of reserve material and the extreme reproductive activity, point to a heavy draft upon the host. I have been unable to find any calculations which might be applied to such organisms as parasites with any likelihood that they would yield even approximate estimates of the material actually consumed. It would seem clear that previous calculations are incomplete and that the draft on the host is far greater than has been imagined heretofore.

An important effect on the host is traceable to the increase in the size of the parasite. This normal accompaniment of growth is most significant when the parasite occupies a limited space or when the increase in size is marked. The brain cysticercus, ordinarily found in a ventricle, grows until the cavity is occupied and then pressure upon the nervous tissue brings a sudden end to the life of the host. A liver hydatid may continue to grow almost without limit and only when important structures become involved is the pressure of serious moment. Most bladder worms do not exceed insignificant limits in growth and consequently exert little or no influence on the host. The echinococcus, through its indefinite growth, is sure to reach a size which will interfere with the activity of the host, and from its usual location in the liver is likely to include important vessels, or nerves, and lead to fatal interference with normal functions.

Another general influence which parasites are thought to exercise on the host is explained by the hypothesis of reflex nervous action. According to this view intestinal parasites affect the host by irritating the nerve terminations and provoking in reflex fashion the varied troubles of helminthiasis which the clinician recognizes. This is a rôle which has been regularly ascribed to them and yet, as Guiart says, this view is in fact a pure hypothesis. It has been invoked as an easy way to explain

the results of parasitism, and though attractive by its very simplicity, no evidence has been elucidated in its support, while at the same time many grounds have been advanced for other views. Accordingly, it is my intention to pass this hypothesis with the mere mention.

It has been frequently noted that parasitic infestation tends to retard the development of the host organism. In fact it does not hinder the general growth of the host strikingly, but arrests primarily its sexual development. This has been especially investigated by Alfred Giard, who denominates the phenomenon parasitic castration and defines it as the sum total of modifications produced by a parasite on the reproductive apparatus of its host, or on the portions of the organism indirectly in relation with that apparatus. The phenomenon appears to be wide-spread, instances being found in all branches of the animal kingdom and as the result of the most varied sorts of parasites. The character of this influence becomes evident through a simple comparison.

When an organ acquires undue importance one of the first physiological results of its hypertrophy is the arrest of sexual reproduction. Similarly when a parasite develops in an organism it causes sterility in its host. Such parasitic castration may be direct or indirect. The first case is met when the parasite destroys directly by mechanical means, or for its nutrition, the genital glands of its host. Parasitic castration is indirect when the producing parasite is not directly in relation with the genital glands, but in some other part of the body of the host. Parasitic castration may also be temporary and then disappear when the parasite is suppressed.

The modifications caused by parasitic castration affect the genital organs, the secondary sexual characters and the sexual instincts of the infested animals; it may be partial to any degree and may exert the same influences on the secondary sexual characters as age or as artificial castration. Each one of the sexes loses more or less its characteristic attributes and tends to acquire in the same degree those of the opposite sex. Thanks to the effective labors of Professor Giard, this phase of the influence of parasites on the host is more carefully worked out in comparative fashion than any other in the entire category. However, it would be clearly impossible within the necessary limits of this address to present the mass of evidence which he has collected from all parts of the animal and plant kingdoms.

A change which is mechanical to a certain extent and yet which has results of far deeper character, is the destruction of tissues by such parasites as actually feed upon the cells of the host animal. This is evidently due to the functional activity of the parasite and for that reason will lie outside of the limits of a purely mechanical process and may be considered here. Schaper has shown that the liver fluke (*Fasciola*) feeds upon the substance of the organ in which it lives. Now this destruction of liver tissue removes from functional activity a certain portion of a most important organ. In addition to that it is followed by a growth of connective tissue, so that there is a permanent loss in the functional activity of the organ. Many different kinds of alimentary parasites actually feed upon the wall of the canal, with the result that by the feeding and burrowing of the parasites through the mucosa this important structure is destroyed over considerable areas; the wall of the canal comes to be covered with ulcers and suffers at these points permanent functional injury. The serious secondary effects in such cases have already been noted and they are evidently not in any sense directly proportioned to the extent of the injury, but the

primary effect upon the functional process of the organ is directly related to the number of such injuries, or, in other words, to the number of parasites at work. Other parasites burrow into the intestinal wall and produce there nodules of various sorts. Nematodes particularly determine the formation of such nodules in various organs of the host.[5] These nodules may be of considerable size, but in any event they involve the destruction of some functional tissue and the consequent impairment of the functional activity of the organ.

Among the physiological activities of parasites none is more striking in its reaction upon the economy of the host than the power that has been acquired by some forms which live upon blood to secrete a substance that inhibits the coagulation of the blood. Leo Loeb and Smith have recently shown that the hook worm secretes in glands of the anterior body region a substance which is exceedingly effective in inhibiting the coagulation of blood. This is antagonistic to the normal reaction of the mucosa. Consequently the points at which these parasites have attached themselves to the membrane become seats of continued hemorrhage, and in case of a numerous infection by the species there are myriads of minute hemorrhages constantly discharging blood[6] into the cavity of the canal. The powerful anemia which is associated with the parasitism of the hook worm receives in this way a ready explanation.

There are many cases in which production of diseased conditions in the host appears distinctly traceable to the presence of a parasite and removable by the removal of the parasite. These diseased conditions are general, not local. They are apparently due to some abnormal stimulation and have usually been explained on the basis of the influence of toxic materials which the parasite produces. That parasitic organisms, like all other animals, produce waste matter and give it off into the fluids by which they are surrounded is not open to question. If the view already advanced of the active metabolism carried out by the parasites, and if the extremely highly developed excretory system are correct indications, then the amount of such waste material eliminated would be proportionately large. It is also undoubtedly true that various investigators have been able chemically to isolate toxic principles from the bodies of various parasites, and that in a number of instances these substances have been tested in their effects on living organisms with the result of producing changes or invoking symptoms distinctly analogous to those which have been recorded as the consequences of infection by the specific parasite. It also appears that the evidence which has been collected heretofore seems to indicate a difference in the degree of the effect exercised by living and by dead helminthes, for the latter are much more

[5] Thus *Sclerostoma equinum* produces tumors on the intestinal lining of the horse; *Spiroptera megastoma* in the submucosa of the horse; *Spiroptera sanguinolenta* in various organs of the dog, fox, etc.; *Œsophagostoma columbianum* in the intestine of sheep; *Strongylus Ostertagi* in the fourth stomach of cattle; *Gnathostoma siamense* in the subcutaneous tissue of man.

[6] As a matter of fact Looss has demonstrated that blood is not the normal food of the hook worm, as these parasites feed on the mucous membrane of the host, and blood is sucked in only when the parasite accidentally pierces a vessel. Looss takes the position that a toxin is produced which acts hemolytically, pointing out the fact that in some fatal cases of severe anemia the number of parasites found in the intestine was too few to explain the severity of the illness. It does not seem to me to be necessary to infer the production of some unknown toxin, since the possession of a secretion inhibiting the coagulation of the blood would account for the persistence of the hemorrhages, and it is this factor of continuance which makes of them dangerous elements. It is well known that the leech also produces such a substance in its glands.

dangerous than the former; and yet it should be remembered that our precise knowledge of these matters is exceedingly limited. The production of a substance by extraction from a parasite is not sufficient evidence that the animal actually eliminates this material. It may be that in the final step of elimination there are changes which radically alter the character of the substance, and that consequently there is under natural conditions no such material in position to act upon the host individual. It should also be remembered in this connection that the parasites are generally located in those organs into which waste is normally eliminated and by which it is discharged from the body; and, furthermore, that the parasitic organism sets free but a small amount of such waste material at any one time. These conditions would appear to indicate a minimum effect upon the host, if, indeed, any such existed.

On the other side, there are also certain incontestable facts. Not only is the recovery of such toxic substances from parasitic organisms by chemical means undoubted, but also it is known that as a result of injury or surgical intervention when a hydatid cyst is ruptured and the liquid content is diffused through the body, there are absorbed from it toxic substances which provoke serious results. Normally, the bladder worm is surrounded by a cuticula which retards osmosis, so that only a negligible quantity of toxin can be dispersed, while the rest is accumulated in the vesicle.

Another argument which has been advanced to question the actual relation of these toxic substances to the pathological conditions of the host is the great amount of variability in different cases, not only as between the effect of different parasites which would naturally be explained on the basis of different types of toxic substance, but also with regard to the effect of the same parasite in different cases. Now this may easily be due to individual susceptibility on the part of the host animal, but there is another feature which would go far towards explaining this variable effect and yet it has never been suggested in this connection. Under certain conditions an animal will absorb toxic substances from its own alimentary canal and induce diseased conditions within itself as a result of this perverted function. The application of the same principle to the case of parasites would account for the absorption of toxic materials by one host and their elimination in another case.

So far as the protozoa are concerned, the evidence is positive that in some cases toxic materials are the cause of the effect produced by the parasite. Thus the Hemosporidia of malaria undergo their development within the red blood corpuscles, and at the time of breaking up into spores the corpuscle is destroyed and the accumulated toxic material set free in the blood. Since the phenomena are synchronous for a large number of the parasites the amount of toxic material set free at once is considerable and is followed immediately by a febrile reaction, the periodicity of which is related to the successive reproductive cycles of the parasite.

The case of the Trypanosomes which are the cause of sleeping sickness is less definitely demonstrated, but apparently of the same type. In this disease no pathogenic changes can be observed in the host save a slight inflammation of the vascular membranes surrounding the spinal cord and brain. The toxins which the organisms in the spinal fluid produce must be set free in this fluid and thus act directly upon the central nervous system with the lethal effect characteristic of the disease. The result here is certainly not morphological and is satisfactorily explained on the basis of the production of a deleterious chemical stimulation.

But little is known regarding the chemical character of the substances under dispute. The indefinite idea that some toxic substance is produced has been replaced in one or two instances by a definite idea regarding the material and its manner of working. Such is the case in hook-worm disease, already discussed, and it may be that more extended study will furnish clearer ideas with regard to other cases. Some observers have determined the substances obtained extractively as leucomaines, while in other cases they have been found to be more nearly like enzymes. Certain of them react upon the blood with marked hemolytic power, while others of the ferment character affect nerve centers. An alkaloid which arrests muscular action has also been isolated.

The most difficult case to explain on any other theory than that of the production of toxic principles is the progressive, pernicious anemia, present in some cases of bothriocephalid infection. In spite of numerous investigations the case still remains obscure, but apparently one must admit that at least in special instances this parasite does excrete a particularly active toxin having hemolytic properties. Undoubtedly, the production of toxins by bacteria leads us to expect similar substances in this case also, but the argument from analogy is a dangerous one in scientific demonstrations. Perhaps the strongest argument in favor of the view that parasites produce toxic substances is to be drawn from the occurrence of eosinophilia, which will be considered next.

Among the white blood cells are such as from the affinity of their granular contents for certain stains are known as eosinophile cells. They constitute from 2 per cent. to 4 per cent. of the normal leucocyte count, and an absolute increase beyond the normal number of 250 per cubic millimeter is designated eosinophilia. The conditions which produce an eosinophilia vary so widely that the cells have been termed the most capricious element of the blood. To a certain extent this seems true of the many varied reports of parasitic invasions on record, as some observers in the case of almost every species record the absence of any eosinophilia. Yet evidence is growing that eosinophilia is a strikingly constant symptom of infections with animal parasites, and experiments on lower animals as well as the most careful and extended observations on man are nearly uniform in their testimony to the existence of abnormal numbers of eosinophile cells in the blood.[7]

Some authors indicate what may be the explanation of the negative results of other observers. Thus Calvert noted in cases of *Filaria Bancrofti* that the development of the eosinophilia followed a cyclical course, being more marked when the embryo round worms are absent from the peripheral blood and decreasing as the embryos increase these. The percentage of eosinophiles varied in one case from 3 per cent. to 15 per cent. during twenty-four hours. The observation has been confirmed exactly by Gulland, while other observers record similar or greater variations, though the minimum figures are higher. In fact, such fluctuations seem characteristic not only for this parasite, but also of most other species. In some cases the eosinophilia does not make its appearance at the first of the infection, and after a marked increase subsequently declines or even disappears as the disease becomes chronic. A reappearance of the eosinophilia and also irregular fluctuations in it during the course of the

[7] Thus tapeworm infection, hydatid cysts, the Egyptian blood flukes, and many other parasites, are associated with an increase in eosinophile cells in the blood. In trichinosis it is the rule and in hook-worm disease the main feature of the blood is an eosinophilia both relative and absolute.

malady are also noted. Such variations have been recorded in infections with tapeworms, with hook worms, with trichinæ and with various filariæ. To what extent predisposition and immunity influence the phenomenon can not be judged at the present time, owing to insufficient data and incomplete observations.

Equally characteristic with these fluctuations one must regard also the excessive degree of eosinophilia in parasitic diseases. While under other conditions an eosinophilia of 7 per cent. to 10 per cent. is usual, with rare instances of 35 per cent. to 50 per cent., in infections with animal parasites 10 per cent. to 30 per cent. is the average and 70 per cent to 80 per cent., or even 87 per cent., the extreme. The number of cases with such high percentages is large, even though the records in general are not numerous, indicating even more distinctly the usual character of the exceptional eosinophilia in such cases.

The intimate relation of the eosinophile cells to the parasite is strikingly indicated by two well-established facts. The first already referred to is the increase and decrease of these cells in the peripheral blood as the embryos of *Filaria Bancrofti* appear in the superficial capillaries and disappear from them. The second was established by Opie experimenting with trichina on guinea-pigs. The increase in eosinophile cells does not begin until the embryos start to migrate and reaches its maximum when the majority of the embryos are in transmission from the intestinal mucosa by way of the lymphatic vessels and the blood through the lungs to the muscular system. Sabrazes also found a great accumulation of eosinophile cells in the vicinity of hydatid cysts. All these facts would seem to indicate not only a stimulus, probably chemical, inducing the multiplication of the cells, but also a positive chemotactic influence which led the cells towards the source of the stimulus. Since the stimulus originates from the parasites, the simplest explanation finds it in the normal emanations of the animal, which as waste matter may be classed under the general category of toxins.

Among the physiological effects of parasitism is listed prominently the production of a condition of deterioration in the blood known as anemia, involving changes in the red blood cells and in bone marrow. In certain cases it has been possible to indicate with some definiteness the cause, as in the hook-worm anemia, already discussed. External parasitism of blood-sucking species, such as leeches or fish lice (argulids) produces anemic conditions through direct appropriation of blood, and if the parasites become numerous, enough is withdrawn to cause the death of the host.

But after the elimination of these instances there remain others in which an explanation can not be given at the present time. The most striking example of such cases is that of the broad fish tapeworm (*Dibothriocephalus latus*) frequently associated with a severe form of pernicious anemia which, indeed, is given the name of a bothriocephalus anemia. Also *Oxyurias* and *Ascaris* have been found less frequently in connection with the same pathological condition, though the connection is not satisfactorily demonstrated. Now in all these instances the amount of departure from the normal may vary from a very slight anemia to the maximum degree, while in many cases there appears to be no such effect from the presence of the parasite. The condition is also distinguishable from pernicious anemia due to inherent causes in that it disappears promptly with the expulsion of the parasites. Experiments made with an extract of the *Dibothriocephalus* injected into various animals have been successful in some cases in producing an anemia, but in other cases have

failed. The reason for this anemia is not loss of blood, and equally contrary to known facts are the various hypotheses, based on the length of stay in the intestine, the predisposition of the host and the condition of the parasite. The view that it is due to a toxin seems at present least open to criticism.

The discussion which has been laid before you in this address involves many terms which are rarely used in zoological circles, and many animals which are perhaps equally unfamiliar. To the average zoologist parasitism is a *terra incognita,* if not a *terra evitata!* The biological problems it presents were among the very first to be indicated, but have not received their proportionate attention in the intervening years. Just now there seems to be awakened interest in the subject and the results of investigations in this field are most hopeful. The subject is one which really overlaps the boundaries of zoology and encroaches upon the field of physiology and of medicine also. Much fine work has been done on the medical side of the topic, but the best results there can not be reached without generous cooperation from this side also. It is eminently fitting in this place to recall the splendid researches on morbific Protozoa carried out by a zoologist on the faculty of Columbia University. There is urgent need for similar work on other groups that the medical investigator may be furnished with those morphological, physiological and biological data upon which the successful prosecution of his studies depends. The work of the zoologists, Howard and J. B. Smith, on mosquitoes made possible the scientific victories of American physicians over disease in Havana and New Orleans. The recognition of hook-worm disease as an important factor in American medicine came through the pioneer work of the zoologist, Stiles. The splendid investigation of Councilman and his confrères on smallpox was not complete without the work of a zoologist, Calkins. The triumphs of modern science are being won by cooperative efforts and these are nowhere more indispensable than in the study of animal life, so peculiarly and closely related is it to the progress of the human race. At no point, however, is the contact more intimate than here where the zoologist is called to join with the investigator in medicine in achieving the amelioration of man's physical condition and the suppression of disease.

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SCIENTIFIC BOOKS

The Wing Veins of Insects. By Professor C. W. Woodworth. University of California Publications, Technical Bulletins, College of Agriculture, Agricultural Experiment Station. Entomology, Vol. I., No. 1, pp. 1–152, September, 1906. Contributions from the Zoological Laboratory of the Museum of Comparative Zoology at Harvard College, under the direction of E. L. Mark. No. 181.

Probably no animal organs have been so minutely compared externally as have the wing veins of insects. Comparison is so easy, so unhampered by preliminary technique, and the significant characters are so tangible and withal so useful, they are universally employed in defining both major and minor groups. There are probably no animal organs that are dealt with in a specific manner by so many workers in zoology. Therefore, when there appears a pretentious work that assumes to extend the knowledge and advance the theory of venation it attracts immediate and wide-spread interest.

Such a work is this recent one by Professor Woodworth. Its purpose is "to develop a theory that will serve for the interpretation of the facts that have been so richly accumulated" (p. 3) and "to establish a rational theory of venation" (p. 143). It aims to cover the whole field, discussing, in order, the

origin of wings, their relation to the body, the mechanics of flight, the basal articulation, vein structure, vein development, the genesis of venation, methods of modification, and venation types. It presents some new and interesting data on the nature of degenerate and metamorphosed veins, and more especially on the mode of articulation of the wings with the thorax; but, in the main, it is a purely theoretical discussion of certain classes of facts previously well known. Professing to be based on studies of twenty-two years, on "microscopical preparations of about two thousand species representing all the principal groups, a much larger series of insects with spread wings, and practically all the published figures of insect wings," it is singularly parsimonious of new facts.

The theory is, in brief, that insect wings have arisen from tracheal gills, that the veins are inherited from gill covers and have no connection with the tracheæ inside, but that "mechanical necessities are the dominant factor in their first production and in their subsequent development," and that the venation collectively evidences three major groups of winged insects, called by the author Neuroptera, Elytroptera and Neoptera.

Gegenbauer's theory of the origin of wings from tracheal gills is accepted, and is defended probably about as well as is possible in absence of good evidence. The gill cover of a single species of Mayfly larva of the genus *Rithrogena* is used in illustration. Unfortunately, this gill cover is one of the most highly specialized for its own peculiar functions, and is quite off the line of possible wing development. Its basal articulation is said to be like that of wings, but it is not described. The diagonal brace across its lower face, cited as 'most convincing evidence' of its relation with wings, would be much less convincing with a little more knowledge of gill covers. Still, notwithstanding that the choosing between theories in this field is a matter of balancing remote possibilities, the presence of basal articulation and musculature in gill apparatus gives the Gegenbauer theory an advantage over Müller's lateral expansion parachute theory. But it does not appear why the suggestions of Dr. Tower, published some years ago in this same series of contributions, should not have been noticed.

The author's treatment of the wing tracheæ is somewhat remarkable. He reluctantly admits that these air tubes sometimes grow in wings, but he does not allow them to appear in any of his wing figures—only in the Mayfly gill cover; and there, apparently, because not coincident in position with the brace which he thinks is like a primitive vein. He seeks by argument as labored as it is unnecessary to prove that they have no air-taking function, while quite ignoring their air-distributing function. Everybody knows that in insects air is carried to all the living tissues of the body, not in blood vessels as in vertebrates, but in tracheæ, and the equanimity with which, throughout this whole discussion, these principal visceral organs of the wings are excluded from consideration is most remarkable. A few quotations will illustrate this: "In many wings, at least, tracheation is a comparatively late and entirely secondary matter" (p. 7). Quite true; but in what wings? In none but those of a few highly specialized groups. Teeth are absent from the jaws of some mammals; but their absence is not better accounted for, nor more disturbing.

"In studying the development of veins, we need only to take into consideration the constant features of the developing wing, the hypodermis of the wing pad and the cuticle that it secretes" (p. 52).

"*Accidents* of structure of a temporary adaptive organ" (p. 62). The italics are mine.

"The venation is conceived of as receiving nothing from the precursor of the wing except veins that were developed in the same way and to meet the same needs with those of the organ after it became adapted to flight" (pp. 144).

He laments that in adopting the Müllerian hypothesis Packard was "not entirely able to divest himself of his former idea of an essential connection between tracheæ and veins" (p. 62). Alas, Packard was not able; neither was that 'prince of entomologists,' Dr. Hagen;

nor was Dr. Brauer; and, doubtless, many another in days to come, observing the individuality and persistence of the tracheæ, and the regular formation of the veins about them, will be unable to ignore them with the serenity of the author.

For, in primitive insects, tracheæ develop first, and the veins later develop about them. That is not theory, but fact; any one may easily see it for himself. The very presence of the tracheæ between the two membranes of the wing when these are fusing sufficiently accounts for the primary location of the veins. Moreover, these tracheæ in generalized wings show all the usual signs of homology: likeness in form, likeness in relations and greater likeness in earlier than in later stages. If these are not good evidence, there are no homologies of any significance. Furthermore, the homologies discovered in the tracheæ are fully corroborated by those of the adult veins, previously ascertained.

The author concludes his argument for the exclusion of the tracheæ as follows: "A large amount of very strong evidence would be needed to explain away the essential identity of structure in tracheated and non-tracheated veins; the evidence obtainable seems to indicate identity rather than difference. We must conclude, then, that the presence or absence of a trachea is an incident of structure of no special significance in comparing veins" (p. 47). Precisely. Just as the presence or absence of teeth in mammalian jaw bones is of no special importance in identifying the bones. Not the presence or absence of either teeth or tracheæ is of chief significance, but the form taken on when present.

The precedence of the tracheæ and the subsequent development of the veins about them is disposed of in this way: "It is impossible to deny that the location of the veins may have been really marked out, though unrecognizable to the eye" (p. 46). This position is, of course, unassailable. Those who can attain to equal faith may find equal security in it.

If a 'rational theory of venation' requires the elimination of the tracheæ in order to get room to grow in, let us take leave of them, as does the author, and then see how the theory thrives. Without attempting to follow in detail the hypothetical explanation of the manner in which veins arise, through the activity of a hypothetical substance secreted by the hypodermis, forming folds or wrinkles, controlled by hypothetical pressures, we find the veins at length appearing after the following hypothetical fashion: first a *marginal vein* about the entire border of the wing, and a *primary vein* along the middle of it in position somewhat like that of the ridge on the under surface of the gill cover figured. Then there appear *anterior* and *posterior veins* in the spaces at either side of the primary, outgrowing from the base of the wing. Finally, a series of *independent veins* is formed by ingrowth from the marginal vein toward the base of the wing; and with subsequent attachments and adjustments of these, the venation is completed.

In this theory of ingrowing independent veins (branches of the median vein) 'a class of veins that never had basal connections,' lies the chief novelty of the paper. It becomes at once evident why the tracheæ have had to be excluded; for the branches of the median trachea are not independent, and they grow outward from the base of the wing like the other tracheæ. It is, indeed, surprising that greater care has not been taken to establish an hypothesis intended for general application on a better basis of facts. The only evidence given to show that these veins are really ingrowing is that they are usually weaker toward their inner ends and are sometimes independent (unconnected) there. The fact that this weakening is most pronounced and that the detached condition occurs in the more specialized members of the several groups is passed by unnoticed. In generalized Lepidoptera, *Hepialus*, the Psychidæ, Cassidæ, etc., these veins have basal connections, and when free proximally, their dislocated basal rudiments within the discal cell might well have been accounted for. In the Ephemeridæ, where the author finds his series of free and primitive independents most highly developed, they are, unfortunately, most free in *Callibætis, Bætis, Chlœon*, etc.—a bunch of genera representing the extreme

of specialization in a highly specialized order. In the Paleozoic Protephemeridæ the author meets (and frankly acknowledges) contradiction from the opposite end of the Mayfly series: "In one point, however, these early wings stand in marked contrast with those of the modern group. It is the absence of free independents. The production of free independents prior to connected ones would seem to be the natural order of evolution, but this evidence certainly does not point that way" (p. 97).

The author's account of their origin is all comprised in the following sentence: "The independents arise from the *margin of the wing*, and might possibly be considered as ingrowing branches of the marginal vein; but, since this portion of the marginal vein is commonly absent, while the independents are almost always present, this conclusion may seem to be unwarranted" (p. 68). Nevertheless, his system is built upon it.

But matters are still worse when viewed from the mechanical standpoint. This theory of veins ingrowing from the hind margin contradicts the primary principle of insect æronautics. For, as is well known, forward motion through the air is due in insects primarily to the sculling action of the wings when vibrated up and down, and that action results from the pliancy of the hind margin. The trend of specialization in the wings of all the orders is toward greater stiffness of the front margin and greater relative pliancy of the area behind it, and the obvious mechanical advantage of this is that they scull in air better. The disappearance of the marginal vein and the fading out of the base of the median, are, owing to position in the wing, the earliest and most expedient contributions to that pliancy. Girard more than half a century ago demonstrated experimentally the detriment to flight of adding weight to that portion of the wing in which these 'independents' are supposed, according to this hypothesis, to originate.

The true order of development is inverted. So it is in the case of the cross veins, whose origin is discussed on page 71. These are supposed, on this special creation theory, to grow up in the clear membrane *de novo*. Special activities of certain cells, occupying the positions that are to be those of veins and cross-veins, are made to account for the appearance of these. But for the assumption that the cells about the vein cavity show greater secretory activity, or produce more chitin, cell for cell, than those outspread in the intervening membrane, there is no proof offered: and it is not clear why the simpler and long current explanation of the differentiation veins from membrane, by accumulation of cells about the vein cavities, and the stretching of those that lie between, does not give a better basis for the application of mechanical principles. For how shall "the more rational conception that there existed in the beginning and has existed through all time to the present day a mechanical necessity in accordance with which the primitive venation was produced, and all its essential features have been maintained through all the vicissitudes of the ages" (p. 62) help us account for anything? It is merely a flow of rhetoric: not an explanation. The mechanical principle were better stated, or at least its operations detailed, with some indications of the material on which it operates. Throughout this paper controlling mechanical principles are heralded as though a new discovery in insect wings, but they never come to light. On the contrary, as we have seen, well-known mechanical principles are flatly contradicted by the theories proposed. Were it not that the principle of vein differentiation is already fairly well understood, this theory of ingrowing independent veins might possibly have made as large a contribution to the confusion of the subject as did that of Adolph, its lineal antecedent.

A reviewer of vein mechanics should have been able to see the primitive dichotomy of the branching of veins. It is a curious survey of insect venation that misses this. Dichotomy abounds in the venation of the oldest known fossils. It occurs in the generalized members of most of the groups. It occurs in the gill covers of many Mayfly larvæ and is beautifully shown in those of *Ephemerella*. It occurs in plants, also, and is the type of

branching of such thallophytes as *Dictyota dichotoma* and such liverworts as *Riccia fluitans*. It occurs, apparently, wherever a branching organ extends itself unimpeded in one plane. Its wide-spread independent occurrence is evidence that it is the result of developmental dynamics, and there can be no doubt it is primitive.

The author thus 'having traced the development of these systems of veins' (p. 73) proceeds with full assurance to the application of his theory. He has no difficulty at all in identifying his marginal vein in the catch on the inner edge of the elytron of Coleoptera (p. 75). It is safe to say that no other venation theorist has ever ridden his hobby so far as this. His primary vein, 'invariably found in functional wings' (p. 63), is absent from at least one of the wings shown on p. 100. With respect to the Odonata-anisoptera, in discussing the triangle, he says: "It does not, nor does the wing of any of the Anisoptera, show any transition between a triangular and a quadrilateral cell." The ignorance of our own fauna and its literature shown by this statement is not more surprising than the readiness with which he ignores the illustrative genera that are mentioned in the legend to the figure he is criticizing. But these and other misstatements concerning the Odonata will not mislead the students of that order. Having ignored tracheation and also the likeness in venation between Plecoptera and Orthoptera, he is able to give a different interpretation of the two orders. But the great superiority of his theory appears in the treatment of the venation of the fossil Homothetidæ (p. 102), Embiidæ (p. 106) and Physopoda (p. 126). Even the last named, for whose puzzle no one has hitherto ventured a solution, is instantly resolved by the application of the 'rational theory'! It is wonderful. The only trouble with it is that it is too easy. When in doubt about a vein call it what it most resembles in the hypothetical diagram. "Class as an independent vein anything that anywhere exhibits structures characteristic of independent veins" (p. 69). Throw away the usual safeguards against misinterpretation of parallelisms: they are all superseded by the application of a mechanical theory!

And when we reach the end of it, we find that its goal is another system of vein nomenclature! This is formally compared, vein by vein, with four[1] (out of the dozens) of systems proposed in the past. It is hard to see why the author, since he identifies all of these in detail including the generally recognized branches, should have thought to advance entomology by a new batch of names for them. It is not easy to understand why, if the new terms *marginal* and *primary*, etc., may be used in an elastic sense, as provided on p. 145, the old terms *costa, radius*, etc., might not, if it were necessary, be so used, equally well.

Other peculiarities of this work are the ignoring the literature of the subject for nearly the last decade and of important papers on the mechanics of insect wings, much older: the misspelling of the names of authors cited, Aaron, de Selys Longchamps and McLachlan (the last in two ways), and evident misstatement of facts, such as this: "An increase in the size of a wing usually results in an increase in the number of veins" (p. 65). There is no justification in morphological experience for the statement that "increase in a wing area would do just the same things that a decrease would undo" (p. 80) and that the "direct effect of environment would be sufficient" to differentiate two groups (p. 9) is surely assuming something. The statement of p. 145 that other workers have not recognized that the same names should be applied only to homologous organs, is a fine bit of assumption. There is a mysticism about the account of the genesis of the venation that is somewhat unusual in a scientific paper: page 79 is full of it; and the statement that the primary vein was developed to be the dominant vein (p. 144) reminds one of the statement of that other narrative of

[1] Those attributed to Comstock are the names selected by Redtenbacher as most available. They were in his day and are now the ones in most common use, and to their adoption no serious objection has ever been offered.

Genesis, that the lights in the firmament of heaven were to be for signs.

It is altogether probable that entomologists, before entering upon the course here marked out for them, will demand a better statement of guiding principles, and a better disposition of the ontogenetic and phylogenetic difficulties that beset the way.

JAMES G. NEEDHAM

Minerals and How They Occur. By W. G. MILLER, Provincial Geologist of Ontario, formerly Professor of Geology, School of Mining, Queen's University. Toronto: The Copp, Clark Company. 1906.

In his intention of producing a book on mineralogy for 'secondary schools and prospectors' the author has succeeded admirably both because of the clearness and simplicity of his style and because of his accuracy of statement. There is room for books of this sort since, though the subject is of wide general interest, there are few sources of information which are attractive to the *beginner.* The average book offered to the beginner is not only inaccurate but lacks successful arrangement and shows poverty of facts and illustrations. Professor Miller's book contains about two hundred illustrations and these give such an idea of the subject as descriptions could not convey. They are new, well selected, and some of them are especially good (*e. g.,* Figs. 20, 47, 63, 79).

The large amount of information contained in the book is in attractive form. Upon looking at the table of contents one might be reminded of Voltaire's essay on dogs in which towards the close he says 'Speaking of dogs reminds me of cats' and proceeds to write a short dissertation on cats. One might think that the paragraphs on fossils were hardly called for a book on mineralogy. But as he becomes acquainted with the author's aim he sees that the book differs from the ordinary one which presents the science in its narrower aspects and that it has been written just as if the author were talking to interested beginners before whom he must needs start with the most obvious things—rocks, the common rocks with which his readers are familiar—and build upon them his edifice. Such work necessitates excursions into the surrounding country and the result is a building all of whose parts contribute to mineralogy.

The more involved parts of the subject are omitted or touched upon but lightly and the things which are apt to prove most attractive to beginners are presented in logical and compact manner.

A few changes might be suggested. Though crystallography is the least palatable side of the subject it is so essential as to require more attention. When the axes of the six systems are being given (Fig. 23) one should not be omitted; the orientation should be according to the almost universal method—*i. e.,* a should always be the axis pointing to the observer, should always represent the short axis in the orthorhombic and triclinic systems, and the inclined axis in the monoclinic system. β should represent the acute angle made by the intersection of c and a and α by the intersection of c and b. All of the simple holohedral forms should be pictured and with the axes drawn in them. Whether combination, twinned and hemihedral forms are presented may well depend on the space at the disposal of the author. But if crystallography is to be mentioned at all the first principles should be given with clearness.

An occasional statement like the following should be modified. "During late years this theory of origin (of petroleum and natural gas) has been questioned by many workers who are inclined to believe that both materials are of inorganic origin" (p. 59). Forty years ago Berthelot suggested that petroleum might have originated from union of carbonated waters with uncombined sodium and potassium and about ten years after that Mendeleef propounded as a possible origin the union of such waters with metallic carbides. Thus the theory can hardly be called a recent one and in addition it appears to be a theory which shows possibilities rather than the facts which the study of oil fields the world over seems to establish. The actual geological conditions in oil fields necessitate the conclusion that oil and natural gas are of organic origin.

The book is full of valuable information

presented in attractive form and for the beginner is one of the best books of its kind with which I am acquainted.

A. R. Crook

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SCIENTIFIC JOURNALS AND ARTICLES

The Journal of Experimental Zoology, Volume III., No. 4 (December, 1906), contains the following papers: 'The Physiology of Regeneration,' by T. H. Morgan. Experiments on salamanders, earthworms and fish show that the rate of regeneration in a posterior direction is more rapid the further the cut surface from the original end. In other words, the more of the old part removed, the more rapid the new part regenerates. Other experiments show that this is not due to food conditions, but that the rate depends on a formative factor. It is suggested that it is the relation of tension in the old and the new part that is a controlling factor in regeneration and growth. 'Hydranth Formation and Polarity in Tubularia,' by T. H. Morgan. Experiments on tubularia show that the polarity is an expression of the direction of the gradation of the differentiated materials. The greater the differentiation in one direction the longer the road that must be traveled to produce a different kind of structure. The gradation acts as a physical factor in development, determining the tension relations in the old and new part. 'Studies on the Development of the Starfish Egg,' by D. H. Tennent and M. J. Hogue. This paper describes the parthenogenetic development of the star-fish egg following treatment with CO_2, the phenomena occurring as a result of first treating the egg with CO_2 and later fertilizing it, and the results of subjecting fertilized eggs to the influence of CO_2. 'Some Experiments on the Developing Ear Vesicle of the Tadpole with Relation to Equilibration,' by Geo. L. Streeter. A study of the normal development of the function of equilibration in the tadpole, and the variations produced by removal and transplantation of the ear vesicle during the early larval period. 'The Relation between Functional Regulation and Form Regulation,' by C. M. Child. The organism is to be regarded as primarily a dynamic or functional complex, and structure and form are visible expressions of dynamic conditions: consequently the regulation of form and structure is fundamentally a dynamic or functional regulation and only as such can its phenomena be satisfactorily interpreted. 'Study of the Spermatogenesis of Coptocycla Aurichalcea and Coptocycla Guttata, with especial reference to the Problem of Sex Determination,' by W. N. Nowlin. An investigation of two species of beetles revealed the presence of an unequal pair of chromosomes, the so-called 'idiochromosomes' of Wilson, which, we have strong evidence for believing, transmit or determine the character of sex. The small one invariably occurs in the male somatic cells and represents the recessive form of the female character; the large one in the female somatic cells and bears the male character. 'Torsion and Other Transitional Phenomena in the Regeneration of the Cheliped of the Lobster (*Homarus Americanus*),' by Victor E. Emmel. A comparison of the regenerative with the ontogenetic method of development. 'The Influences of Gases and Temperature on the Cardiac and Respiratory Movements in the Grasshopper,' by Eulalia V. Walling. The influences of gases and temperature on the respiratory and cardiac activities were found to be practically the same on segments of the isolated heart and isolated respiratory centers as in the normal grasshopper. Moreover, it was found that these activities may continue in such specimens as long as four days in an atmosphere of pure hydrogen.

DISCUSSION AND CORRESPONDENCE

NORTON'S ELEMENTS OF GEOLOGY

The review of Norton's 'Elements of Geology,' which appears in a recent number of Science, Vol. 24, p. 590, prompts one to repeat the suggestion recently made, that the legitimate function of a review in such a periodical as Science is to give to the reader an accurate impression of the general character of the work, both as to the ground which

it covers, and as to the way in which it covers it.

It may be doubted whether the review in question performs this function. It leaves the impression that the book reviewed is, on the whole, a pretty poor sort of book, when it is really an excellent one. It is not beyond criticism—no book is. The reviewer indicates some of the weak points, and seems to regard as weaknesses several of the strong features. A number of the criticisms might be appropriate if the book were intended primarily as a reference work, but they hardly seem applicable to a book which is intended as a text-book for beginners. An excellent text-book is not necessarily the best book for reference. The classification of subject matter for ideal books of the two types would be, in many respects, very different. In a text-book, it is certainly no weakness that one must 'go to three or four separate parts of the book' 'to learn about sandstones,' though this might be a weakness in a book of reference. The reviewer's attitude leads one to suspect that he uses books for reference only, not as texts, and that this has influenced his point of view.

In spite of the reviewer's statement, the diagrams of the book are, on the whole, excellent and readily understood, and the notes and questions which accompany them are to be especially commended.

The criticism that the book is largely physiographic is nothing against it, and when we remember the class of pupils for whom the book is intended—high-school pupils—the absence of 'references to other books' is certainly much less serious than the reviewer seems to think.

The statement that 'the bog ore, silicious and phosphatic deposits that get a brief mention in Le Conte are not here referred to' leads one to make the further suggestion that a book should be carefully read before detailed criticism of this sort is indulged in, for bog ore is mentioned on page 53 and silicious deposits on pages 52, 178 and 261. Other similar criticisms of the reviewer might be cited. The omission of such subjects as phosphatic deposits is to be commended in a book of this type, for it must be remembered that most elementary books treat of too many, not too few, topics. In the writer's judgment the book takes rank at once among the best of the elementary text-books on geology.

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UNIVERSITY OF CHICAGO,
December 10, 1906

SPECIAL ARTICLES

THE SIGNIFICANCE OF THE GRASPING ANTENNÆ OF HARPACTICOID COPEPODS

THE character of the secondary sexual differentiation of the first pair of antennæ of male free-swimming Copepoda and the associated manner of copulation divide these copepods into two well-marked groups: one group in which only one antenna forms a grasping organ and in which the act of copulation is relatively short; and a second group in which both antennæ are grasping organs by which the male holds the female for a long time in copula. The duration of this union is shown by two records: one of an apparently normal pair of *Harpacticus uniremis* which remained in copula at least twenty-nine and possibly thirty-eight hours; another of a pair of undetermined genus which remained in copula eight days, at the end of which both male and female died. The persistence of the male is shown by the fact that he can be torn apart, but still maintains his hold until the paralysis of death frees the female. Claus[1] observed that the males of the Peltidiæ were found in copula with females one molt from maturity and speculated upon the meaning of the phenomenon without arriving at a satisfactory conclusion.

During the spring of 1906, a large number of copulating pairs of *Harpacticus uniremis* and *Tachidius littoralis* appeared in the tow taken in Narragansett Bay and a number of pairs were separated in watch glasses for observation. We were fortunate in examining a pair of the first species just when the female was beginning to molt. The ecdysis occupied about five minutes and as the slough came away, the male, which had been holding the female by the hinder edge of the carapace,

[1] Claus, C., 'Die freilebenden Copepoden,' Leipzig, 1863, p. 71.

dropped the cast and grasped the female between the abdomen and thorax, and, moving around from the dorsal surface of the female, deposited the spermatophore in its place upon the genital segment. He then freed the female and made no attempt to renew his hold. In six days the female produced eggs which hatched in seven days.

Despite a great deal of effort, we have never again been able to observe the molt and subsequent copulation, but we have complete evidence that, in three species of two genera (*Harpacticus uniremis, H. gracilis* and *Tachidius littoralis*), the spermatophore is never attached before the female molts, and that, in every case, the male holds the female until she molts. Whenever a normal pair, left a short time before in copula, were found separated, careful examination revealed the cast of the female in the watch glass and a spermatophore attached to the female. In other words, every successful copulation must be prolonged until the female molts.

The longest period in copula observed with a successful issue was between twenty-nine and thirty-nine hours. In two cases the female died in molt, an antenna and a furcal bristle respectively being caught in the cast. In several instances the male, the female, or both died before the molt, probably because of the abnormal conditions of the experiments. In one case the male of a copulating pair was killed and, after the female had molted, another male was introduced, but no copulation took place.

These observations are by no means the first of this character, for there is a general impression among students of Crustacea that ecdysis and copulation or ovulation are closely connected processes. There is evidence that copulation follows a molt of the female in several crabs[2] and in the isopod Gnathia.[3] There is also evidence that ovulation follows the molt in some isopods and amphipods.[4] Finally, Della Valle[5] finds that the male of *Gammarus pungens* holds the female until she molts, assists in freeing her from the cast, and then deposits the sperm.

The males of Amphipoda, Isopoda, *Artemia* and related Phyllopoda, *Limulus,* and of the Copepoda of the group under discussion all have the same habit of carrying or holding the female and all have structures modified for this purpose. Hence, it is possible—it is even probable—that this habit and these structures indicate that, in these forms, the female must molt before fertilization can be accomplished.

Our attempts to find the meaning of this presumably general habit of the Crustacea mentioned have been unsuccessful, but we believe that the softened condition of the shell may be necessary for the attachment of the spermatophore or the extrusion of the eggs.

Leonard W. Williams

[2] See Herrick, F. H., 'American Lobster,' Fish, Comm. Bull., 1895, p. 39. Williamson, H. C., 'Contributions to the Life History of the Edible Crab, *Cancer pagurus*,' Rep. Fish. Board, Scotland, V., 22, 1904. Barnes, E. W., 'Natural History of the Paddler Crab, Callinectes hastatus,' 34th Report Comm. Inland Fisheries of Rhode Island, p. 69, 1904.

[3] Smith, G., 'Metamorphosis and Life History of *Gnathia maxillaris*,' *Mitt. Zool. St. Neapel*, XVI., pp. 469–471, 1904.

[4] Langenbeck, C., 'Formation of the Germ Layers in the Amphipod *Microdentopus gryllotalpa*,' *Jour. Morphology*, XIV., p. 303. See also Korschelt & Heider, 'Text-book of Embryology' (English translation), Vol. II., p. 105.

[5] Della Valle, A., 'Gammarini del Golfes von Napoli,' Fauna and flora des golfes von Neapel, 20, p. 276, 1893.

BLOWING SPRINGS AND WELLS OF GEORGIA, WITH AN EXPLANATION OF THE PHENOMENA[1]

The blowing springs and wells of Georgia may be divided, for convenience of description, into two classes, namely, those in which the air passes inward for a time and after a short period of quiescence reverses its course, and those in which the quantity of the air is constant and moves in one direction only. One of the best illustrations of the former class of springs is the Grant Blowing Spring, near Chattanooga, Tennessee, a description of which is as follows:

The Grant Blowing Spring is located at the base of Lookout Mountain near the Georgia-Tennessee state line about three miles from the corporate limits of Chattanooga. The

[1] By permission of the state geologist.

spring has long been known and is much frequented by tourists visiting Chattanooga. It may be reached by the Alton Park electric cars, or by the Chattanooga Southern Railway. The proximity of the spring to Chattanooga and its accessibility has doubtless added much to its notoriety.

In general appearance the spring is not unlike many other bold springs met with along the eastern base of Lookout Mountain. It flows from a fissure, at the base of a limestone bluff, forming a good-sized stream. The spring itself reveals but little evidence of the phenomenon for which it is noted. Nevertheless, the phenomenon can readily be detected by holding a smoldering match or lighted paper near the opening from which the water flows. The motion of the air is to be seen in its full force at an opening in the bluff above, about forty feet distant, and at an elevation of ten or fifteen feet above the spring. At this opening, which leads down to the stream supplying the spring, there is, at times, a strong current of air passing inward or outward, depending on the atmospheric conditions hereafter to be discussed. The writer was informed by Mr. W. H. Grant, the present owner of the spring, that the opening above referred to was formerly of sufficient size to admit the body of a man; and furthermore, that he, together with a civil engineer, some years ago entered the opening which led into a cave having large chambers fifteen feet or more in height. The distance to which the cave was explored by Mr. Grant and his companion was not measured, but it was estimated to be nearly a mile. The direction of the cave is said to be southward parallel with Lookout Mountain. Mr. Grant reported that they noticed no current of air in the cave. This, however, may be accounted for by their using a lantern which would not be affected except by a strong draught. The stream forming the spring was found traversing the cave as far as the exploration extended, and many stalactites and stalagmites were reported in the larger chambers.

The formation in which the cave occurs, and from which the spring flows, is one of the lower members of the Carboniferous rocks known as the Bangor limestone. It consists of a very pure heavy-bedded blue or grey limestone attaining a thickness, in the neighborhood of Chattanooga, of about 800 feet. In the immediate vicinity of the blowing spring, the formation dips at a low angle westward toward the axis of Lookout Mountain. The Bangor limestone is highly soluble in meteoric waters and frequently gives rise to limestone sinks and caves of greater or less extent.

At the writer's suggestion, Mr. Grant made a series of observations on the blowing spring in order to determine the time and direction of the air currents, together with the relative temperature of the water flowing from the spring and the outside air. The results of the observations, which extended from December 21 to December 26 inclusive, are embodied in the following table:

TABLE I.

	Time		Temperature		Direction of Current	
Date	A. M.	P. M.	Air	Water	In	Out
Dec. 21	8		46	52	Weak	
21	noon		50	55	Strong	
21		4	48	55	Strong	
22	8		36	54	Strong	
22	noon		42	56	No current	
22		4	46	56		Weak current
23	8		43	56	Strong	
23	noon		42	54	Strong	
23		4	40	56	Strong	
24			27	53	Strong	
24	8		38	54	Strong	
24	noon	4	33	55	Strong	
25			28	52	Strong	
25	8	4	38	56	Not so strong	
25		10	30	55	Strong	
26	4		26	54	Very strong	

The following barometric readings furnished by Mr. L. M. Tindell, officer in charge, U. S. Weather Bureau, Chattanooga, Tenn., show the variations of the atmosphere pressure during the time of Mr. Grant's observations.

The tables here given will be further considered at the end of this paper in the discussion of the explanation of blowing springs and wells.

TABLE II. HOURLY BAROMETRIC READINGS, U. S. WEATHER BUREAU, CHATTANOOGA, TENN., DECEMBER 21 TO 26 INCLUSIVE

Date	21	22	23	24	25	26
1 a. m.	28.85	29.30	29.09	29.35	29.42	29.45
2	.87	.30	.07	.36	.42	.45
3	.90	.30	.06	.34	.42	.45
4	.42	.30	.08	.34	.42	.45
5	.94	.33	.09	.34	.42	.45
6	.97	.33	.13	.35	.43	.45
7	.28	.33	.13	.36	.43	.44
8	29.02	.34	.15	.37	.44	.45
9	.04	.34	.20	.39	.45	.47
10	.05	.34	.2	.39	.44	.47
11	.05	.32	.24	.38	.43	.45
12 m.	.05	.28	.25	.37	.40	.41
1 p. m.	.05	.24	.24	.36	.38	.37
2	.06	.22	.24	.36	.38	.35
3	.08	.22	.26	.36	.38	.34
4	.10	.21	.26	.36	.39	.33
5	.13	.19	.28	.37	.40	.33
6	.18	.19	.29	.40	.42	.33
7	.21	.19	.30	.41	.43	.32
8	.24	.18	.32	.42	.44	.32
9	.25	.15	.33	.44	.45	.32
10	.29	.14	.34	.44	.45	.33
11	.29	.11	.33	.43	.45	.32
12 m.	.29	.06	.33	.42	.45	.32

Boston Well.—The Boston deep well belongs to the second class of blowing wells, namely, wells in which the direction of the air current is in one direction only. Boston, the town in which the well is located, is on the Atlantic Coast Line Railroad, in the southeastern part of Thomas County, twelve miles east of Thomasville. It has an elevation of 198 feet above the sea-level. The surface of the surrounding country is comparatively level, though lime sinks, produced by the subterranean stream, are occasionally met with. The prevailing rock of the region is Vicksburg-Jackson limestone overlain by sands and clays of variable thicknesses.

The well, which is six inches in diameter, has a depth of 290 feet. Water was reported at 120, 160 and 286 feet, respectively. The main water supply at present is said to come from a subterranean stream in the limestone at 120 feet. The casing extends to 110 feet. The static head of the water in the well when completed was 128 feet from the surface, or eight feet below the subterranean stream. Shortly after the completion of the well, Mr. J. Z. Brantley, the mayor of the town, discovered that there was a continuous draught of air passing down the casing, and by placing his ear near the mouth of the well he was able to detect a sound like running water. This indraught, Mr. Brantley reports, was quite strong and continued as long as the well was left open. The writer was unable to verify Mr. Brantley's statement at the time of his visit, owing to the well being connected with the pump which supplies the town with water.

The Lester Well.—This well, reported by William Miller, which is also similar to the Boston well, occurs on B. E. Lester's plantation, twenty miles south of Thomasville, near Iamonia Lake. Mr. Miller, in describing this well, says that at a depth of 154 feet he struck a stream of water running so swiftly that he could not pass a two-pound iron plumb bob attached to a fishing line through it. He reports blowing crevices in the well at 87, 124 and 144 feet. When the well was being bored the air from each of these cavities is said to have passed in in the forenoon and out in the afternoon; but after the completion of the well to the swift moving subterranean stream, the air ceased to pass outward, but was sucked in with a strong steady pull, drawing the flame and smoke of a torch down the casing when held six inches above its opening. This well is cased to 70 feet, below which point it is said to penetrate a soft white limestone.

Causes of Blowing Springs and Wells.—The two classes of blowing springs and wells above described appear to be due to two entirely different causes. Those of the first class, of which the Grant blowing spring is a good type, seem to be due entirely to the difference of atmospheric pressure of the air on the outside and on the inside of the cave.

At the time of my visit to the Grant blowing spring, I was of the opinion that the relative temperatures of the air on the outside and on the inside of the cave, the latter temperature being indicated by the water flowing therefrom, had something to do with the air currents; but the record furnished by Mr. Grant (see Table I.) shows that the direction of the currents has nothing whatever to do with these relative temperatures. That these currents are due solely to the variation of atmospheric pressure appears to be con-

clusively demonstrated by comparing Tables I. and II. The first of these tables shows, with only two exceptions, namely, at noon and 4 P.M. December 22, that at the time when the observations were made there was an ingoing current. Table II., which gives the barometrical readings, shows that the time of recorded ingoing currents, except at noon, December 24, was during the time of increasing atmospheric pressure; and that in the two exceptional cases, which showed outgoing or no currents, the atmospheric pressure was decreasing. In other words, the outgoing currents always take place during rising barometer, and ingoing currents during falling barometer. As the atmospheric pressure usually increases daily from 4 A.M. to 10 A.M. and decreases from 10 A.M. to 4 P.M., it follows that springs, wells and caves of this class will generally have an indraft in the forenoon and an outdraft in the afternoon. If the daily variations of atmospheric pressure were regular, the ingoing and outgoing currents would also be regular and would take place at the same time each day. However, as the daily maximum and minimum barometric readings may vary greatly from day to day, due to approaching storms or other causes, the ingoing and outgoing currents will not always act with the same energy.

In the second class of wells and springs, the constantly outgoing or the constantly ingoing current is entirely independent of atmospheric conditions. The currents, whether outward or inward, act with equal energy during high or low barometer and always move in the same direction. The Boston and the Lester deep wells are excellent examples of wells and springs of this class. The phenomenon which they exhibit seems to be due entirely to the friction of the air on a rapidly moving current of water. This phenomenon is beautifully illustrated in Richard's water air-blast, to be found in many well-equipped chemical laboratories. In the Boston well, and also in the Lester well, appear almost exactly the same conditions met with in Richard's water air blast. The well itself forms the inlet for the air, and the rapidly flowing stream in the subterranean channel below completes the conditions necessary for an ingoing air blast. As the air in the wells here named is constantly drawn in, it naturally follows that it must escape at some other point as an outgoing current, thus giving rise to continuously blowing caves or springs.

As underground streams frequently pass from one bed of rock to another in their subterranean course, they, no doubt, often form waterfalls which possess all the essential conditions necessary for producing an air blast, thus giving rise to continuously blowing caves and springs.

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CURRENT NOTES ON LAND FORMS

GLACIATION OF THE BIG HORN MOUNTAINS, WYOMING

A RECENT report on the 'Geology of the Big Horn mountains' by N. H. Darton (Prof. Paper 51, U. S. Geol. Surv., 1906; excellent plates) describes the range as a wide anticline with steeper dips on the east, eroded sufficiently to expose its granitic core over the broad arching crest, while scalloped ridges of the more resistant members lie along the flanks and in places stretch over toward the axis of the range. R. D. Salisbury presents a chapter on glaciation—in which there is to our view an insufficient recognition of the previous work of F. E. Matthes on the same district—showing that many glaciers occupied the upper valleys during the last glacial epoch. Erosion by these glaciers, working in valleys that had been previously developed by normal preglacial erosion, is held responsible for 'the development of cirques, the cleaning out of the upper parts of the valleys through which the ice passed, the rounding and widening of the valley bottoms, the polishing of the rock surfaces in the valleys and the excavation of some of the lake basins.' The cirques head in superb cliffs, which rise abruptly to the broad highland surface of the unglaciated granite; sharply serrate ridges occur where the widening of neighboring cirques and troughs has consumed the intervening highland surface; here the mountains gain a dis-

tinctly Alpine form. As to the strength of glacial erosion in excavating the valley troughs, it is said that 'not a few of the valleys may have been deepened 400 to 700 feet in their upper parts, while in some cases * * * the deepening may have been considerably more.' In view of this, explicit mention of 'valley deepening' as well of the 'rounding and widening of valley bottoms' might have been made in the list of features for which glacial erosion is held responsible, as quoted above. Here, as in so many other glaciated valleys, the depth of the glacial tarns, many of which occur in the upper reaches of the valleys, is by no means a full measure of the depth of glacial erosion—the rock basins simply indicate an excess of erosion at one point over that next down-valley, a fact which might have been more clearly presented. Hanging lateral valleys occur but are not numerous; nevertheless they certainly deserve a place in the list of 'the distinctive features of glaciated mountains,' where for some reason they are omitted.

The morainal deposits, which occur where the local glaciers ended in the descending valleys on the mountain flanks, are discussed in some detail; good examples of moraines and morainal lakes are figured. About half of the lakes of the district—all of small size—are of this origin; the other half occupy glacially excavated rock basins higher up the valleys, as already indicated. Changes in drainage due to glacial erosion are noted, an example of glacial capture previously reported by Matthes being here figured. (The titles of two figures illustrating this 'capture' have been by oversight interchanged.) A case is cited in which a glacier failed to remove all the decayed rock at a certain point, while rock surfaces not far away show severe wear. Although this is a minor feature, and certainly to be expected as a common result of glacial activity, the citation is of importance in connection with other cases of larger area where the failure of a glacier to remove decayed rock has been urged as evidence of inefficiency of glacial erosion in general. The facts, as here recorded, again emphasize the principle that glaciers, like rivers, erode vigorously in one place, feebly in another, and make extensive deposits in a third.

D. W. J.

GLACIAL EROSION IN THE HIMALAYAS

It has been frequently remarked by those who are still unconvinced of the capacity of glaciers to deepen valleys and excavate lake basins, that the absence of valley lakes in the glaciated districts of the Himalayas is strong testimony on the negative side of the problem. The reply has been made that the glaciated parts of the Himalayan valleys probably had so strong a slope in preglacial time that the overdeepening by glacial erosion did not produce profound lakes, and that such lakes as were produced have already been filled with waste by the heavily loaded rivers of those lofty and often barren mountains. But a specific example of glacial erosion in the inner Himalayan region east of the vale of Kashmir, has recently been described by Ellsworth Huntington, under the title, 'Pangong, a glacial lake in the Tibetan plateau' (*Journ. Geol.,* XIV., 1906, 599–617), from which it appears that valley glaciers have actually produced lakes there, as well as in other mountain ranges. Pangong, or Pangkong, at an altitude of 14,000 feet, about 40 miles long and 142 feet deep (as stated by Drew), is the distal member of a series of lakes of which the total length is 105 miles, with a maximum breadth of four miles. The enclosing mountains rise in steep slopes for the first 1,000 or 2,000 feet, and then at gentler slopes 3,000 or 4,000 feet more to peaks 20,000 feet in altitude. Large moraines, old enough to be much eroded, are found some twenty miles down the main valley from the end of the lake. Glaciated knobs are found along the valley floor, perched erratics occur up to 600 feet over the lake surface, and at least one lateral valley hangs distinctly above the main valley. Pangong does not overflow at present; its surface is thirty-five feet lower than a barrier, a mile farther down the valley, which Drew took to be an alluvial fan formed by a side stream, but which Huntington gives good reason for regarding as a rock sill or inequality in the deepened valley floor. The glacial

origin of this string of lakes thus seems to be reasonably well attested. Postglacial climatic changes, indicated by abandoned shore lines, are discussed in some detail.

W. M. D.

POSTGLACIAL AGGRADATION OF HIMALAYAN VALLEYS

The possibility that glacially overdeepened Himalayan valleys have lost their lakes in consequence of postglacial aggradation, as suggested at the beginning of the preceding note, is supported by the features of the Shigar valley, northeast of the vale of Kashmir, as described in an admirable essay on 'Die Thäler des nordwestlichen Himalaya,' by K. Oestreich, topographer of the Workman expedition, 1902, and now Docent in Marburg University (*Peterm. Mitt. Ergänz'hft*, 155, 1906: 36 exceptionally fine plates). This valley was invaded by huge glaciers from the lofty Mustag range on the north, where glaciers of great size still remain; and Oestreich points out the strong contrast between the broad glaciated trough of the Shigar and the narrow gorge of the Indus which the Shigar joins, the village of Skardu lying near the junction. The Indus in its northwestern intermontane course follows for 150 miles (except near Skardu, as stated below) a young gorge, eroded some 200 meters beneath the floor of an earlier, larger and more mature valley: the sides of the gorge show numerous ledges between incompletely graded slopes; the bottom has no continuous flood plain, but only local sandbanks at the base of the convex spurs; the road can not follow the river, but has to rise and fall on the spurs of the valley side. The Shigar valley, on the contrary, is described as having been widened and deepened by glacial action: it has a broad, aggraded floor, on which the river divides and wanders in a braided course: the valley sides are glaciated and carry patches of glacial deposits. The barren slopes of the desert mountains are believed to have aided in supplying waste with which to aggrade the overdeepened valley. Similar features are found also in a middle portion of the Indus valley—the Skardu basin—for some twelve miles below the entrance of the Shigar; and again, to a less degree, for some twenty miles farther up the Indus to the entrance of the Shayok, which like the Shigar brought in a great glacier from the north. Before the Skardu basin was filled with gravel, there is much probability that it contained a lake.

It is singular to note that, although Oestreich ascribes the deepening and widening of the Shigar valley to glacial erosion, he explains its continuation in the Skardu basin as the result of tectonic movements: the glaciers did not, he says, deepen the basin by erosion, but the deepening of the basin by deformation attracted the glaciers to it. The text is unfortunately not detailed enough to enable the reader to reach an independent judgment.

W. M. D.

UPLIFTED PENEPLAINS IN THE HIMALAYAS

In a later section of the essay referred to in the foregoing note, Oestreich gives an excellent description of the highlands of Déusī—the Deosai plains of English travelers—and accounts for them as an uplifted and not yet dissected peneplain. They have a somewhat circular area, 24 kil. in diameter, and stand at an altitude of from 3,800 to 4,000 met.; their gently undulating surface, sometimes surmounted by subdued hills, shows no sympathy with the deformed structure of their mass. Mountains rise around them to 5,000 met. except on the southeast, where their streams escape. The whole surface has been glaciated, and is now clothed in summer with grass and flowers. It is pointed out that the Déusī highland is the only example of its kind on the near side of the river Indus, but that similar highlands exist farther inland, especially in Tibet.

It thus would seem that, as far as this part of the Himalaya is concerned, it falls in with a number of other mountain ranges—as recently pointed out for the Alps by Penck, for the Carpathians by Martonne, for parts of China by Willis, to say nothing of various ranges in the United States—in owing its altitude not to the deformation by which its disordered structure was caused, but to a broad uplift which took place long enough after the

period of deformation for erosion to have greatly lessened or almost destroyed whatever unevenness of form the deformation produced.

W. M. D.

A MATHEMATICAL EXHIBIT OF INTEREST TO TEACHERS

For the benefit of students and teachers of mathematics who may be visiting Columbia University, the department of mathematics in Teachers College has arranged a permanent exhibit of material available for the study of the history and teaching of the subject. One feature of the exhibit is a collection of mathematical apparatus and models adapted to the needs of the various grades from the kindergarten through the high school, including games, mensuration blocks and models usable in geometry and trigonometry.

In addition to Professor Smith's library of several thousand books and pamphlets upon this subject, there is also available his collection of mathematical instruments—some dating as far back as 1450—of manuscripts, and of engravings and portrait medals of eminent mathematicians.

The early mathematical instruments exhibited include the following: an astrolabe of Arabic workmanship; one of Italian workmanship, signed by the maker, and dated 1509; another, a part dating from about 1450, and the rest, including the four plates, from the following century; and one of Paduan workmanship, signed by the maker, and dated 1557, a practically perfect specimen, with five finely engraved plates. There is also a quadrant of the sixteenth century, one of the primitive instruments of trigonometry, bearing the early names 'Umbra recta,' and 'Umbra versa,' together with several leveling instruments of the seventeenth and eighteenth centuries. There are also numerous measures of length and weight, of the seventeenth and eighteenth centuries, including the ell and some interesting sets of money changers' weights; several finely engraved protractors, diagonal scales, and similar instruments; several sector compasses and compasses of other kinds, of the Renaissance period; a collection of typical forms of dials to illustrate the application of mathematics to dialling in the Renaissance period, and several armillary spheres of the sixteenth, seventeenth and eighteenth centuries.

The material used to illustrate the development of mechanical calculation includes the following: a collection of medieval counters (jetons, reckoning pennies) of fifteenth and sixteenth century workmanship, partly French and partly German, some with the figure of the Rechenmeister seated at the abacus. Books showing the process of calculation by means of counters 'on the line' are also exhibited. There are also to be seen an Arabic abacus, a Russian tschotü, a Chinese swanpan, a Japanese saroban, a set of Napier's rods, and a set of Korean bones (the modern form of the ancient Chinese 'bamboo rods,' or the Japanese Sangi). Some Japanese books of 1698 are exhibited showing the transition from this latter form of computing to the saroban, which took place in Japan about that time. Besides these there are shown several modern calculating machines, including the Goldman and Stanley arithmometers, slide rules, and similar devices. There are also available for study, in addition to those displayed, several early treatises showing the use of counters, together with numerous works on the historical development of this phase of arithmetic. This is also extensively illustrated in a collection of stereopticon slides belonging to the department.

There are in Professor Smith's library about two thousand portraits of mathematicians. Of these it is possible to exhibit only a relatively small number. About forty are framed and can readily be examined, and visitors wishing to examine others in the collection are assisted in doing so. This part of the collection represents the work of a number of years and the repeated examination of the stocks of many European dealers. It is particularly rich in the works of early engravers, although containing a considerable number of photographs and modern process portraits. Reproductions of a number of the portraits have been made for school and college use by The Open Court Publishing Co., of Chicago.

The collection of Newtons includes all

the most important portraits of this great mathematician and physicist. An effort has also been made to acquire all the best portraits of Leibnitz, Descartes, Euler, the Bernoullis, Legendre, Monge, Cauchy and others who stand out as particularly prominent in the creation of pure mathematics. The collection also includes the portraits of many who have achieved success in the field of applied mathematics, notably of men like Laplace, Lagrange, Huyghens, Bailly and Arago.

Many of these portraits have been reproduced in stereopticon slides for the use of the department, and copies are supplied to schools at cost.

The collection of medals of mathematicians includes more than a hundred pieces. The following are among the most prominent mathematicians represented: Fr. Arago, Archimedes, Aristotle, Bailly, Betrand, Bonnet, Tycho Brahe, Cardan, Cassini, Cauchy, Cavalieri, Copernicus, d'Alembert, De Moivre, Descartes, Euler, Fermat, Galileo, Gassendi, Gauss, Grandi, Halley Hutton, Huygens, Kepler, Lacroix, Lagrange, Lalande, Laplace, LeVerrier, Lobachevsky, Maurolicus, Monge, Neudorffer, Newton (seven medals), Pascal, Pestalozzi, Poinsot, Poisson, Pythagoras, Quetelet, Stevin, Thales, Viviani, Wolf, Wren.

The complete set of mathematical portrait medallions by David d'Angers is included. In addition to the portraits there are numerous other medals of interest in the history of mathematics, including the rare Metric System piece of 1872.

Another interesting feature of the exhibit is Professor Smith's collection of autographs of mathematicians. On account of space, it is possible to exhibit only a few of the several thousand autographs in the library. The following are among the most interesting, and are shown in one of the wall cases: Newton—a two-page manuscript demonstration written for one of his students at Cambridge; Leibnitz—an autograph letter relating to a series of integrals; autograph letters of Sir William Rowan Hamilton, Euler, Johann Bernoulli, Mersenne (written about 1625), Maupertuis, Legendre, Wronski and Arago; documents signed by Gauss, Laplace, and Lagrange; autograph letters from Poncelet to Liouville, Liouville to Dirichlet, and Arago to Poncelet. Autograph letters of the following mathematicians have been taken from the files so as to be accessible, and are usually displayed: in pure mathematics—Jacobi, Cayley, Sylvester, Kronecker, Cremona, Hachette, Poincaré, Hermite, Clebsch, Cauchy, Chasles, Clifford, Binet, Bezout, Monge; in astronomy—Bode, Airy, Delambre, the three Cassinis, Maskeleyne, Flamsteed, Flammarion; in physics—Ohm, Bessel; in the history of mathematics—Montcula, Fuss, Libri, Kästner, P. Tannery, M. Cantor.

In the line of Newtoniana there are five framed portraits of Newton, as follows: Mezzotint by Simon, after Thornhill; line engraving by George Vertue, after Vanderbank; line engraving by Houbraken, after Sir G. Kneller; lithograph by G. B. Black, after Wm. Gandy; line engraving by E. Scriven, after Vanderbank. There are seven medals of Newton, representing the work of Croker (bronze and silver), Dassier, Roëttiers, and Petit (two specimens), besides one without the artist's name. The Newton manuscript was long in the library of Professor Jacoli, at Venice. It consists of a physical demonstration written by Newton at Cambridge, for an Italian student, c. 1700. The impression of Newton's Galileo seal is from the original which was recently presented to the South Kensington Museum. The bust of Newton is after the original by Roubillac. The unframed portraits, numbering over one hundred, include specimens of the work of the following engravers: Phillibrown, Zeelander, Lips, Romney, Fry, Rivers, Scott, Tardieu, Ridley, Goldar, Cars, Laderer, Le Cœur, Freeman, Seeman, Krauss, Ravenet, Guadagnini, Holl, McGahey, Conquy, Zuliani, Cooke, Le Keux, Normand, Landon, Baumann, Wedgwood, Dupin, Smith, Edwards, Desrochers, Weber and others.

There are also displayed a number of books and curios illustrating certain steps in the history or the teaching of mathematics. These include a Babylonian cylinder with

cuneiform numerals, a piece of ancient Egyptian pottery with the zodiacal signs, Roman coins illustrating certain unusual forms in the ancient numeral system, some English tally sticks of 1296, two Renaissance compotus medals, and a celestial sphere of the sixteenth century.

The bibliographical curios include one of the few copies saved from the fire which destroyed most of the first edition of Libri's 'Histoire des Mathématiques' (Vol. I.), with Libri's autograph marginal notes. There are also autograph presentation copies of Laplace's 'Théorie des Probabilités' and of Halliwell's 'Rara Mathematica,' over a hundred unpublished autograph letters of Prince Boncompagni on the history of mathematics, numerous first or early editions of works by such writers as Newton, Descartes, Tartaglia, Cardan, Bombelli, Paciuolo, Euler and Barrow, a number of the earliest editions of Euclid, an unpublished French translation of Cantor's 'Mathematische Beiträge zum Kulturleben der Völker,' from the library of Chasles, and various similar works of bibliographical interest.

THE COMMITTEE OF ONE HUNDRED

At the meeting of Section I of the American Association for the Advancement of Science held in New York on December 29, 1906, Professor Irving Fisher, of Yale University, reported for the 'Committee of One Hundred' of which he is chairman. This committee was appointed in accordance with a vote of Section I at its meeting last July, in Ithaca, its purpose being to consider the best methods of securing the establishment of a national department or bureau of health. This vote was taken in consequence of a paper on this subject read at the Ithaca meeting by Professor J. P. Norton. There had been previous attempts to secure a national department of health, notably those of the American Medical Association, which for twenty years has reported favorably on the subject, but has been unable to secure a large interest in the project, outside of the medical profession. The present movement is not a medical movement, although the medical profession is fully represented in it. The movement was endorsed on December 13 by the joint conference at Washington of the legislative committee of the American Medical Association and the National Council on Medical Legislation before which the first draft of a bill was read prepared by Representative Barchfeld to establish a national department of health. The following is the list of the committee of one hundred as at present constituted:

COMMITTEE OF ONE HUNDRED OF SECTION I. OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, APPOINTED TO CONSIDER METHODS OF ESTABLISHING A NATIONAL DEPARTMENT OF HEALTH

Appointed from the A. A. A. S.

Dr. Wm. H. Welch, pres. A. A. A. S. and of State Bd. of Health of Maryland; professor of pathology, Johns Hopkins University.

L. O. Howard, secretary of the A. A. A. S.; chief bureau of entomology, U. S. Dept. of Agric.

Professor Irving Fisher, chairman of the committee of 100, and of the Economic Section of A. A. A. S.; prof. of political economy, Yale University.

J. Franklin Crowell, Sec. of Economic Section of A. A. A. S.; Editor of *Wall Street Journal*.

Professor J. P. Norton, author of paper on national health department read before the American Association for the Advancement of Science, on the basis of which the committee was appointed; prof. of political economy, Yale University.

Professor James McKeen Cattell, editor, Science, the official organ of the A. A. A. S.; prof. of psychology, Columbia University.

Appointed from the United States Government.

Dr. Robert M. O'Reilly, surgeon general, U. S. Army.

Dr. P. M. Rixey, surgeon general, U. S. Navy.

Col. William C. Gorgas, sanitary officer, Isthmian Canal.

H. W. Wiley, chief, bureau of chemistry, Dept. of Agric.

Dr. Cressy L. Wilbur, chief statistician, Vital Statistics, U. S. Census.

A. C. True, director, office of experiment stations, Dept. of Agric.

Chas. P. Neill, commissioner of labor, Dept. Commerce and Labor.

James R. Garfield, chief bureau of corporations, Dept. Commerce and Labor.

Gifford Pinchot, chief forester, Dept. of Agric.

Max J. Baehr, U. S. Consul, Cienfuegos, Cuba.

A. D. Melvin, chief of bureau of animal industry, Dept. of Agric.

Amos P. Wilder, U. S. Consul, Hong Kong, China.

Gen. Leonard Wood, Gov. of Moro Province, Philippines.

Appointed from State and Local Governments.

Dr. A. C. Abbott, health officer of Philadelphia.

Dr. Thos. Darlington, health officer of New York.

Dr. Alvah H. Doty, health officer, Dept. of Quarantine, N. Y.

Dr. John S. Fulton, sec. Maryland State Bd. of Health.

Professor Chas. Harrington, sec. Mass. State Bd. of Health; prof. hygiene, Harvard Medical School.

Dr. Charles D. Smith, State Bd. of Health, Portand, Me.; prof. physiology, Bowdoin College; supt. Maine Gen. Hospital.

Appointed from Medical and Hygienic Institutions and Associations.

Dr. Joseph Bryant, pres.-elect Amer. Med. Association.

Dr. Geo. H. Simmons, sec. Amer. Medical Association.

Dr. Chas. A. L. Reed, chairman Legislation Com. of Amer. Med. Association.

Dr. Hermann M. Biggs, pres. Nat. Assoc. for the Study and Prevention of Tuberculosis.

Professor Livingston Farrand, sec. Nat. Assoc. for Study and Prev. Tbc.

Dr. C. O. Probst, sec. Amer. Pub. Health Assoc. and Ohio State Bd. of Health.

Professor L. Emmett Holt, sec. Rockefeller Institution.

Dr. J. H. Kellogg, supt. Battle Creek Sanitarium.

Dr. E. L. Trudeau, Adirondack Cottage Sanitarium, Saranac Lake, N. Y.

Dr. Prince A. Morrow, pres. Amer. Soc. Sanitary and Moral Prophyl.

Dr. Dudley A. Sargent, pres. Boston Health League.

Dr. Luther H. Gulick, pres. Amer. Physical Education Society.

Appointed from Physicians and Hygienists.

Dr. Frank Billings, pres. Assoc. Amer. Physicians; prof. of medicine, Rush Medical College, Chicago.

Dr. Henry B. Favill, prof. of therapeutics, Rush Med. College.

Dr. P. M. Jones, ed. *Jour. California Med. Assoc.*

Professor E. O. Jordan, ed. *The Journal of Infectious Diseases*, Chicago.

Dr. Quitman Kohnke, formerly health officer, New Orleans, Covington, La.

Dr. Richard C. Newton, formerly ed. *Jour. N. J. Med. Assoc.*, Montclair, N. J.

Appointed from Other Associations and Institutions for Human Betterment.

Felix Adler, pres. Ethical Culture Assoc.

Miss Jane Addams, Hull House, Chicago, Ill.

C. Loring Brace, sec. Children's Aid Society.

Mrs. Melvil Dewey, sec. Lake Placid Conf. on Home Economics.

Professor S. M. Lindsay, sec. Nat. Child Labor Com.

E. R. L. Gould, pres. City and Suburban Homes Co.

Mrs. Ballington Booth, Volunteers of America.

Edw. T. Devine, gen. sec. Charity Organ. Soc., N. Y.

Rev. Josiah Strong, pres. Amer. Institute of Social Service.

John Graham Brooks, pres. Nat. Consumers' League.

Adna F. Weber, sec. Amer. Assoc. for Labor Legislation.

Professor Jeremiah W. Jenks, pres. Amer. Econ. Association.

Robert Treat Paine, pres. Amer. Peace Assoc.

Daniel C. Gilman, pres. Nat. Civil Service Reform League.

William R. George, 'George Junior Republic.'

Robert S. Woodward, pres. Carnegie Institution, Washington, D. C.

J. Eugene Whitney, sec. People's University Extension Soc., N. Y.

Austin G. Fox, chairman, Public Health Defense League.

Experts on Various Phases of Health Work.

Professor Francis G. Benedict, prof. of chemistry, Wesleyan University.

Dr. Jaques Loeb, prof. of physiology, Univ. of California.

Professor M. E. Jaffa, prof. of chemistry, Univ. of California.

Professor Ellen H. Richards, prof. of sanitary chemistry, Mass. Inst. of Technology.

Professor Franklin C. Robinson, prof. of chemistry, Bowdoin College.

Professor F. F. Wesbrook, prof. of pathology and bacteriology, Univ. of Minnesota.

Professor Sam'l H. Woodbridge, prof. of heating and ventilating, Mass. Inst. of Technology.

Appointed from Educational Institutions.

Pres. James B. Angell, pres. Univ. of Michigan.

Dr. J. S. Billings, librarian, Pub. Libraries, New York City.

Professor R. H. Chittenden, director, Sheff. Scientific Sch., Yale University.

Pres. Chas. W. Eliot, pres., Harvard University.

Pres. Arthur T. Hadley, pres., Yale University.

Pres. G. Stanley Hall, pres., Clark University.

Miss Hazard, pres., Wellesley College.

Booker T. Washington, supt., Tuskegee Inst.

Clergymen and Lawyers.

Rev. Lyman Abbott, ed. *The Outlook.*

Rev. W. G. Eliot, Portland, Oregon.

Rev. C. H. Fowler, M. E. Bishop, N. Y. City.

Rev. Edw. Everett Hale, Chaplain, U. S. Senate.

Rt. Rev. John Ireland, Archbishop of St. Paul.

Professor James B. Ames, Dean Harvard Law School.

Hon. Ben. B. Lindsey, Juvenile Court, Denver, Col.

Hon. John D. Long, Ex-Sec. of Navy; Ex-Gov. of Mass.

Hon. Wm. K. Townsend, Judge U. S. Circuit Court of Appeals.

Additional Members.

Professor Liberty H. Bailey, prof. of agriculture, Cornell University.

Luther Burbank, horticulturist, Santa Rosa.

Andrew Carnegie, philanthropist.

James H. Causey, health and political reform, Denver, Col.

Miss Grace H. Dodge, Working Girls' Clubs, New York City.

Thos. A. Edison, inventor.

Horace Fletcher, writer on health.

Professor Harry A. Garfield, prof. of politics, Princeton.

Professor Franklin H. Giddings, prof. sociology, Columbia University.

Professor C. R. Henderson, prof. of sociology, University of Chicago.

Mrs. Mary F. Henderson, writer on health.

John Mitchell, pres., United Mine Workers.

Melville E. Stone, gen. manager, Assoc. Press.

Talcott Williams, editor.

Michael Vincent O'Shea, prof. of education, Univ. of Wisc., Madison, Wisc.

Certainly if eminence and determination count for much, the committee as above enumerated ought to succeed. The committee consists of persons of large influence, including, as it does, such men as President Eliot, of Harvard University, Professor Welch, president of the American Association for the Advancement of Science, Mr. Andrew Carnegie, Mr. Thos. Edison, Luther Burbank, Gen. Leonard Wood, Dr. L. Emmett Holt, Dr. Trudeau, Felix Adler, Jane Addams, Lyman Abbott, Archbishop Ireland, etc. The few who have been compelled to decline membership on the committee have in almost every case expressed their approval of its objects. Thus ex-President Grover Cleveland wrote: "I hope I need not say to you that I am in complete sympathy with the aims and purposes of this organization." In somewhat the same manner Dr. Andrew D. White, former president of Cornell University and Ambassador to Germany and Russia wrote: "The paper enclosed from Dr. Norton seems to me masterly and thoroughly well adapted to its admirable purpose. I need hardly say that I am in entire sympathy with your movement."

Professor Fisher is now engaged in selecting a sub-executive committee which will draft a bill for congress and plan the future campaign. The committee of one hundred is not as yet pledged to support any particular form of organization for the proposed department or bureau of health, and its first duty will be to decide whether it is advisable to attempt to secure a department with a cabinet officer at its head or a bureau under one of the existing departments.

SCIENTIFIC NOTES AND NEWS

Professor Dimitri Ivanovitch Mendeleef, the eminent chemist, director of the Russian Bureau of Weights and Measures, died at St. Petersburg on February 2, at the age of seventy-three years.

Sir Michael Foster, professor of physiology at Cambridge from 1883 to 1903, secretary of the Royal Society from 1881 to 1903, president of the British Association in 1899, and member of parliament for London University, died on January 29, at the age of seventy-one years.

The French government has made Professor Simon Newcomb, U. S. A. (retired), commander of the Legion of Honor.

A bill has been reported in the senate promoting to be major-surgeon in the army Dr. James Carroll, curator of the Army Medical Museum and professor of pathology in George

Washington University, for his investigations on yellow fever.

PROFESSOR WILLIAM JAMES, of Harvard University, our most eminent student of philosophy and psychology, celebrated his sixty-fifth birthday on January 11, and retired on January 22 from the active work of his chair. Professor James is at present giving a course of eight lectures on 'Pragmatism: a new name for an old way of thinking,' before the departments of philosophy and psychology of Columbia University.

THE Cullum medal of the American Geographical Society has been awarded to Dr. Robert Bell, F.R.S., chief geologist of the Canadian Geological Survey.

THE University of Edinburgh has conferred the honorary degree of doctor of laws on the Prince of Monaco for his scientific investigations.

MR. ALEXANDER AGASSIZ has left on the yacht *Virginia* for a scientific cruise in the West Indies.

DR. EDWARD L. NICHOLS, professor of physics in Cornell University, president of the American Association for the Advancement of Science, has left for a trip abroad. He expects to visit Algeria and Sicily and to spend several months in Europe, returning to the United States in September.

DR. WILLIAM TRELEASE, director of the Missouri Botanical Garden, left St. Louis on January 24 for an expedition to the West Indies which will last about two months.

DR. GORDON will, during the present summer, carry on ethnological researches on behalf of the Peabody Museum, Yale University.

PROFESSOR EMIL VON BEHRING, of Berlin, will spend some time at Capri, for the recovery of his health.

PROFESSOR FRIEDRICH VON ESMARCH, professor of surgery at Kiel, celebrated his eighty-fourth birthday on January 9.

PROFESSOR GEO. W. JONES, professor of mathematics at Cornell University, will retire at the end of the present year, after thirty years of service in the institution.

MR. FREDERICK T. GATES has succeeded Mr. Robert C. Ogden as chairman of the general education board, endowed by Mr. Rockefeller with $10,000,000.

ROBERT M. CHAPIN, instructor in chemistry at Amherst College, has accepted a position as assistant chemist in the Bureau of Animal Industry.

PROFESSOR JOSIAH ROYCE, of Harvard University, is giving a series of five lectures at the University of Illinois. His general subject is 'Loyalty as an Ethical Principle.' The special topics of the five lectures are: 'The Problem of Ethics'; 'Four Ideals of Personality'; 'Loyalty as a Personal and Social Ideal'; 'Loyalty as a Factor in American Life'; 'Personality and Immortality.'

PROFESSOR R. S. CHITTENDEN, of Yale University, will lecture at the University of Illinois during the month of May on 'The Physiology of Nutrition.'

DR. ELMER E. BROWN, U. S. Commissioner of Education, will deliver a course of lectures at the summer school of Yale University.

PROFESSOR W. SOMERVILLE, recently appointed Sibthorpian professor of rural economy at Oxford University, delivered his inaugural address on February 1, his subject being 'The Place of Rural Economy in the University Curriculum.'

DR. HOWARD A. KELLY, professor of gynecology in the Johns Hopkins University, is preparing an illustrated cyclopedia of American medical biography, to be issued in several volumes. The work will include sketches of the careers of all the medical worthies of the United States and Canada from the earliest times to our own day.

IT is proposed to found an invalid home for physicians and a medical library in honor of the twenty-fifth anniversary of the death of the Russian surgeon Porogoff.

PROFESSOR WILBUR SAMUEL JACKMAN, who held the chair of teaching of natural science in the School of Education of the University of Chicago and was principal of the elementary school, known for his publications on

nature study, died on January 28, at the age of fifty-two years.

Dr. George B. McElroy, for many years professor of mathematics at Adrien College, died on January 29, at the age of eighty-six years.

The death is announced of Mr. Frederick Stearns, a business man of Detroit, who made archeological collections, which he presented to the University of Michigan, the Detroit Museum of Art and other institutions.

Miss Agnes Mary Clerke, known for her writings on astronomy, died in London, on January 20, aged sixty-four years.

Professor Adam F. W. Paulsen, director of the Danish Meteorological Institute, died in Copenhagen on January 11, at the age of seventy-four years.

The deaths are also announced of Dr. Michael Konowalow, professor of chemistry and director of the Polytechnic Institute at Kieff, and Dr. Ennon Jürgens, professor of mathematics at the Technical School at Aachen.

The Liverpool School of Tropical Medicine sent Professor Ronald Ross, C.B., last year to Greece to study the question of the prevalence of malaria there. As the result of that visit the school has made a strong effort to raise funds in England for combating malaria in Greece and has despatched to Sir Francis Elliot, British minister at Athens, £200, being the amount of the first donations collected.

At a meeting held at Brussels on January 29 at the residence of Minister of State Beernaert, it was resolved to organize a new Belgian Antarctic expedition.

The Peabody Museum of Yale University has received the geological and archeological collection of the Ingham Institute, which came into the possession of the University by the bequest of William Lampson.

Arrangements have been made to establish at Chemnitz a training school for aeronauts and constructors of air ships. A similar school has been in operation in Paris for a year past. A one year's course is contemplated for the present, the school to be opened in May, 1907. This course, at the outset, is limited to the construction and use of balloons. It will be enlarged so as to include aeroplanes, as soon as practical working types have been developed.

Reference was made in the issue of Science for January 25 to the establishment during convocation week of the 'American Entomological Society,' whereas it should have been the 'Entomological Society of America.' The American Entomological Society was organized February 22, 1859, as 'The Entomological Society of Philadelphia,' was incorporated under this title, under the laws of Pennsylvania, April 11, 1862, and changed its name to The American Entomological Society, February 23, 1867. Since 1876 it has been located in the Academy of Natural Sciences of Philadelphia. The thirty-second volume of its *Transactions* is now being published; the present president is Philip P. Calvert, Ph.D.

The London *Times* states that the fourth annual meeting of the Association of Economic Biologists opened at Cambridge on January 9, in the pathological department of the university. The objects of the association are to discuss new discoveries, to exchange experiences, and carefully to consider the best methods of work; to give opportunity to individual workers of announcing proposed investigations, so as to bring out suggestions and prevent unnecessary duplication of work; to suggest, when possible, certain lines of investigation upon subjects of general interest; and generally to promote and advance the science of economic biology in its agricultural, horticultural, medical and commercial aspects. The work of the association includes the various problems connected with economic botany, such as the fungoid diseases of plants and animals; those connected with economic zoology, such as the many problems in connection with insects and other animals injurious to crops, live stock, animal parasites, etc., the scientific cultivation of plants and breeding of animals, and the questions affecting the various natural history products that enter into commerce. The attendance included Professor F. V. Theobald, the outgoing

president, Mr. A. E. Shipley, the new president, Mr. F. Darwin, Professor Nuttall, F.R.S., Mr. R. H. Biffen, Professor Carpenter, Dr. Macdougall, Professor Howard Marsh, Dr. Freeman, Dr. Williamson, Professor Robinson, Mr. C. Warburton, Mr. Herbert Stone, and Mr. Walter E. Collinge (hon. secretary). The report of the council noted the steady growth in the numerical strength of the association; with thirty-one members elected at this meeting there was now a membership of 112. Mr. Shipley's address was on 'Sea Fisheries.'

REFERRING to the plebiscite of eminent Frenchmen recently reported in this journal *The British Medical Journal* says: "A Paris newspaper recently invited its readers to reply to the question, who are the ten greatest Frenchmen of the nineteenth century? Fifteen million votes were recorded, with the interesting result that Pasteur was at the head of the poll with 1,300,000 votes. His majority over Victor Hugo, who was second, was 100,-000. Napoleon was fourth. Among the ten men in the list were the late Professor Curie and Dr. Roux of the Pasteur Institute. The others were, with the exception of one or two men of letters, politicians such as Carnot, Thiers and Gambetta. The list is interesting as showing the high place which science holds in the popular mind of France. How different would the result of a like appeal to public opinion be in this country! The general composition of such a list of the 'greatest men' of Great Britain might easily be foretold. It would include politicians, preachers, two or three soldiers, and one or two popular novelists; science, and particularly that applied to the art of healing, would be nowhere. When the Order of Merit was created there was naturally a good deal of difference of opinion as to the names proposed. There was one name as to which disagreement could scarcely have been expected; yet in more than one of the alternative lists suggested the name of Lister was conspicuous by its absence. This particular form of stupidity scarcely exists in France. It may be, as has been suggested by M. Jules Clarétie, that the choice of Pasteur shows that the gratitude of the French people goes out towards the man who saves life rather than to 'the saviour of society' or the 'idle singer of an empty day.' We are inclined to think that there is more than this in the preeminence accorded to a man of science—that there is appreciation of the value of knowledge for its own sake, and appreciation of the work of those who add to it. But even on the assumption that Pasteur has been pronounced the greatest Frenchman of the last century by the selfish regard of his countrymen for their own well-being, is it not a striking proof of the intelligence of a people that it can perceive the worth of such a man? It is surely a disgrace to us that the name of Pasteur is probably better known in this country as a bogey of obscurantists than as one of the founders of scientific medicine."

WE learn from the London *Times* that through the generosity of Mr. W. A. Cadbury, the valuable collection of *algæ* made during the last thirty years by Mr. E. M. Holmes, F. L. S., curator of the Pharmaceutical Society's Museum in Bloomsbury-square, has been acquired for the botanical department of the University of Birmingham. The collection includes about 13,000 specimens, and has the reputation of being, apart from the national collections at the British Museum and Kew, the best collection of *algæ* in Great Britain. In certain respects it is, indeed, unique, in that the British portion of the collection, largely the outcome of Mr. Holmes's personal activity as a collector, includes three or four species which have been found but once. The foreign portion of the collection is as nearly complete as it could be made. All the specimens are well displayed and mounted, since it had been throughout the collector's aim that they should not remain in private hands, but be fitted in all ways for public purposes. Mr. W. A. Cadbury has desired, as a condition of gift, that the collection shall be accessible to algologists generally, at times and under conditions which may be convenient to the staff of the botanical department of the university.

AT the monthly general meeting of the Zoological Society of London held on Jan-

uary 17, the report of the council for the month of December last was read by the secretary (Dr. P. Chalmers Mitchell, F.R.S.), in which it was stated that during that month 150 additions had been made to the society's menageries—viz, 67 by presentation, 16 by purchase, two received in exchange, 61 received on deposit, and four born in the gardens. Amongst these special attention was directed to a pair of Siberian dholes (*Cuon alpinus*), from Thian Shan, received in exchange on December 2, new to the collection; to a Cape hunting-dog (*Lycaon pictus*), from South Africa, purchased on December 1; to an Addax Antelope (*Addav naso-maculatus*), from North Africa, presented by the Duke of Bedford on December 18; and to a Bubaline Hartebeest (*Alcelaphus bubalinus*) and a hybrid between Père David's deer (*Elaphurus davidianus*) and the red deer (*Cervus elaphus*), deposited on December 29. The report further stated that the number of visitors to the society's gardens during the month of December had been 15,405, showing a decrease of 4,112 visitors as compared with the corresponding month of the year 1905, caused by the inclement weather experienced during the Christmas holidays. The total number of visitors during the year 1906 had amounted to 896,423, or an increase of 180,943 as compared with the total number of visitors (715,480) during the year 1905. The report also stated that the total amount of money received for admission at the gates had amounted to £22,359 2s. 2d., against the sum of £17,469 6s. 4d. received from the same source during the year 1905. The total number of fellows elected during the year 1906 had amounted to 371, showing an increase of 62 as compared with the total number of fellows (309) elected during the year 1905.

UNIVERSITY AND EDUCATIONAL NEWS

Rensselaer Polytechnic Institute has received a gift of $1,000,000 from Mrs. Russell Sage. The money will be used for the School of Mechanical and Electrical Engineering. Mrs. Sage has also given $1,000,000 to the Emma Willard School of Troy, and $250,000 to the international committee of the Young Men's Christian Association.

The establishment and permanent endowment of Peabody College for Teachers, at Nashville, Tennessee, is now assured. The Tennessee legislature has just passed a bill donating to the college $250,000. The city of Nashville has given $200,000 and the county of Davidson $100,000, making in all from these sources $550,000. These gifts have been made in response to a proposition from the Peabody Education Board to endow the college with $1,000,000 when the above amounts were available All the conditions imposed by the Peabody Board have now been complied with and it only remains for that board to organize the institution. The college will thus have $1,550,000 in money. In addition to this, the university of Nashville has donated the campus and buildings now occupied by the college, valued at $250,000. It is understood also that gifts will be received at once from other sources amounting to about $1,000,000. Should this hope be realized, the college will start on its new life with an endowment of $2,000,000. It is the purpose of the authorities of the institution to solicit other funds for the erection of the necessary buildings.

By the will of Arthur Mills, of Brookline, Harvard University will ultimately receive $150,000.

Professor Schuster has offered to the University of Manchester during the next three or four years an annual sum of £350 as the stipend of a reader in mathematical physics.

Through the death of Mrs. John Daglish, Armstrong College, Durham, will receive a bequest of $25,000 for the establishment of a traveling fellowship in mining.

Dr. Ellis E. Lawton, instructor in Yale University, has been appointed associate professor of physics.

The University council of Liverpool University has elected Mr. Percy E. Newberry to the Brunner chair of Egyptology and Mr. John Garstang to the John Rankin chair of methods and practise of archeology, both of which chairs were recently established by Sir John Brunner, M.P., and Mr. John Rankin.